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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS

VOL. XLIV.

1894–95.

EDITED BY M. WALTON BROWN, SECRETARY.

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NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

AUGUST 4TH, 1894.

MR. A. L. STEAVENSON, RETIRING PRESIDENT, IN THE CHAIR.

THE LATE MR. T. H. M. STRATTON.

The following letter was read :—

CRAMLINGTON HOUSE, NORTHUMBERLAND,
JULY 7TH, 1894.

DEAR SIR,—Will you express, to the Council of The North of England Institute of Mining and Mechanical Engineers, my sincere thanks for their kind sympathy and condolence with me and my children in our sad bereavement and terrible grief. My dear husband valued his privilege of membership in your Institute, and often wished that he had possessed more time and ability to further its interests.

I am, dear Sir,
Yours faithfully,
KATHLEEN HELEN STRATTON.

M. Walton Brown, Esq.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on July 21st and that day.

ELECTION OF OFFICERS.

The PRESIDENT appointed Messrs. J. T. Todd, A. M. Potter, W. E. Nicholson, and Luke Thursby as scrutineers of the balloting papers for the election of officers for the year 1894-95. These gentlemen afterwards reported the result of the ballot as follows:—

PRESIDENT.

Mr. T. DOUGLAS.

VICE-PRESIDENTS.

Mr. W. ARMSTRONG.
Mr. T. W. BENSON.
Mr. W. F. HALL.
Mr. J. L. HEDLEY.
Mr. GEORGE MAY.
Mr. J. G. WEEKS.

COUNCIL.

Mr. W. ARMSTRONG, Jun.
Mr. T. W. ASQUITH.
Mr. W. C. BLACKETT.
Mr. T. FORSTER BROWN.
Mr. T. E. FORSTER.
Mr. W. H. HEDLEY.
Mr. T. HEPPELL.
Mr. H. LAWRENCE.
Mr. C. C. LEACH.
Sir W. T. LEWIS.
Prof. J. H. MERIVALE.
Mr. H. PALMER.
Mr. A. M. POTTER.
Mr. H. RICHARDSON.
Mr. R. ROBINSON.
Mr. T. O. ROBSON.
Mr. SIMON TATE.
Mr. W. O. WOOD.

Mr. DOUGLAS thanked the members for the compliment they had paid him in electing him as the President for the ensuing year. He had considerable hesitation in accepting the office, not from any want of desire, but anxiety that everything should be done for the interests of the Institute, and from the fact that his health had been lately of a somewhat precarious character. Associated as he had always been with the Institute from the first meeting in 1852, however, he thought it was his duty to accept the office, knowing that he would have the consideration of all the members of the Institute, and that the Council of the Institute would assist him in every possible way. He moved that a very hearty vote of thanks be accorded to Mr. Steavenson for his services in the Presidential chair during the past year. He had known the President personally perhaps longer than any other member present, and it was a pleasure to him to

propose this vote, as Mr. Steavenson had devoted an amount of time and energy to the Institute, not only this year, because he happened to be the President, but during the whole of the very long time that he had been connected with the Institute.

Mr. W. C. BLACKETT seconded the resolution, which was carried with acclamation.

The CHAIRMAN, in acknowledging the vote of thanks, said he was sorry that circumstances over which he had no control had perhaps prevented him from carrying out the duties of the position as he would have liked; however, they might be sure he would continue to do all that he could to promote the interests of the Institute.

Mr. J. T. TODD moved, and the CHAIRMAN seconded, that a hearty vote of thanks be accorded to the Vice-Presidents and to the members of the Council for their valuable services during the past year.

The motion was agreed to.

The CHAIRMAN moved, and Mr. BLACKETT seconded, that a vote of thanks be accorded to the scrutineers for their services, which was agreed to.

The Annual Reports of the Council and of the Finance Committee were read as follows:—

ANNUAL REPORT OF THE COUNCIL.

The continued increase in the number of the membership during recent years is shown in the following table:—

	August 1st.		
	1892.	1893.	1894.
Honorary Members...	24	25	26
Members	545	565	624
Associate Members	35	47	53
Associates	34	47	68
Students	35	34	20
Subscribing Collieries	18	22	22
Totals	691	740	813

One hundred and nineteen members of all classes have joined the Institute during the year, and after allowing for the losses, through death, resignations, and non-payment of subscription, the net increase is 73. The members may be congratulated upon the increasing prosperity of the Institute, and the Council desire them, at all times, to promote its claims and advantages, and to extend the membership.

The Explosives Committee have carried on investigations at the experimental station, and they anticipate being able to issue the report upon "flameless explosives" in presence of gas, before the end of the year. The appliances and apparatus were inspected by several of the members of the Royal Commission on Explosions from Coal-dust in Mines, who expressed great satisfaction with the experiments and results obtained by the committee.

The "Report of the Prussian Fire-damp Commission," translated by Dr. P. P. Bedson and Mr. L. L. Belinfante; and "Mining Explosives: Their Definition as Authorized under the Explosives Act (1875)," by Mr. A. C. Kayll, have been of great use to the Committee. The papers on "A Contribution to our Knowledge of Coal-dust," by Dr. P. P. Bedson and Mr. W. McConnell, and on "The Combustion of Oxygen and Coal-dust in Mines," by Mr. W. C. Blackett, will also be of value when explosives are tested in presence of coal-dust. Mr. J. D. Kendall's paper on "Miss-fires" confirms some of the results obtained and the practice of the Committee in their experiments.

The library has been maintained in an efficient condition during the year. The additions by donations, exchange, and purchase have been:—

Bound volumes	265
Pamphlets, reports, etc.	245
A total of	510 titles.

And there are now at least 6,666 volumes and 1,267 unbound pamphlets, etc., in the library. Owing to this large increase, bookshelves have been placed in the corridor adjacent to the lecture-theatre, and ample space has been thus obtained for further additions to the library.

The Wood Memorial Hall, lecture theatre, etc., are now lighted by electricity, which has materially added to the convenience of these rooms.

The Watson collection of mining-plans and papers has been placed in the corridor, where they may be examined, but not removed, by members.

The reservation of a reading-room has been under consideration, and the Council request the views of members upon the question.

The fifth volume (S—T) of the "Sinkings and Borings" has been completed, and may be purchased by the members. The Council trust that the remaining volumes will be issued at early dates.

Members who desire to complete their sets of the *Transactions* and other publications of the Institute may now do so at the recently revised prices.

The files of some of the *Transactions* of societies in the library are incomplete owing to loss of volumes or parts, and it is desired that members will return the missing volumes.*

The value of the library would be materially increased if members and friends would kindly present books, maps, etc., which can be spared from their own libraries.

The Federated Institution of Mining Engineers has now been in existence for five years, and during the last year general meetings have been held at Glasgow on September 5th, 6th, and 7th, 1893; at Leeds on February 14th, 15th, and 16th, 1894; and at London on June 7th, 8th, and 9th, 1894. The meetings have been well attended, and the status of the Institution enhanced by the papers communicated and the accompanying discussions. With continued energy on the part of the Federated Institutes, The Federated Institution of Mining Engineers should include the whole of the societies interested in mining and metallurgical engineering.

The report of the committee on mechanical ventilators is approaching completion, and will, it is hoped, be issued during the current year to the members.

The Council have requested Prof. J. H. Merivale to represent the Institute at the conference of delegates of corresponding societies at the ensuing meeting of the British Association for the Advancement of Science at Oxford.

Prizes of books have been awarded to the writers of the following papers, communicated to the Institute during the year 1892-93 :—

"Use of Cement in Shaft-sinking." By Mr. Bennett H. Brough.

"Observations on Fans of Different Types Working on the same Upcast Shaft." By the Rev. G M. Capell.

"Manometric Efficiency of Fans." By the Rev. G. M. Capell.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

* See list accompanying the Annual Report of the Council for 1892.

"Steam Boilers with Forced Blast: the Perrett System for Burning Dust and Rejected Fuels; with Notes on Testing Boilers." By Mr. Bryan Donkin, Jun.

"The Gold-bearing Veins of the Organos District, Tolima, U.S. Colombia." By Mr. Edward Halse.

"The Education of Mining Engineers." By Prof. J. H. Merivale.

"The Geology and Coal-deposits of Natal." By Mr. R. A. S. Redmayne.

"Gold-mining in Brazil." By Mr. E. M. Touzeau.

The papers communicated to the Institute have been:—

"A Contribution to our Knowledge of Coal-dust, Part II." By Dr. P. Phillips Bedson, D.Sc. (Lond.).

"A Contribution to our Knowledge of Coal-dust, Part III." By Dr. P. Phillips Bedson, D.Sc. (Lond.), and Mr. W. McConnell, Jun.

"The Combustion of Oxygen and Coal-dust in Mines." By Mr. W. C. Blackett.

"History and Description of the Greenside Silver-lead Mine, Patterdale." By Mr. W. H. Borlase.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

"The Ghorband Lead-mines, Afghanistan." By Mr. A. L. Collins.

"Note on the Antimony Deposit of El Altar, Sonora, Mexico." By Mr. Edward Halse.

"Note on the Occurrence of Mercury at Quindiú, Tolima, U.S. Colombia." By Mr. Edward Halse.

"Description of the Whitehaven Collieries." By Mr. H. M. James.

"Mining Explosives: Their Definition as Authorized under the Explosives Act (1875)." By Mr. A. C. Kayll.

"Miss-fires." By Mr. J. D. Kendall.

"A Short Description of the Hæmatite Deposit worked by the Salter, Eskett, and Winder Gill Mines, and the Method of Working It." By Mr. J. D. Kendall.

"Singareni Coal-field, Hyderabad, India." By Mr. J. P. Kirkup.

"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.

"Historical Sketch of the Whitehaven Collieries." By Mr. R. W. Moore.

"Description of the St. Helens Colliery, Workington." By Mr. G. Scoular.

"Presidential Address." By Mr. A. L. Steavenson.

"Magnetic Declination and its Variations." By Prof. H. Stroud.

"Minerals and Mining in Tasmania." By Mr. A. P. Wilson.

The Council congratulate the members on the success of the general meeting recently held in Cumberland and Westmorland, and consider

that the best thanks of the Institute are due to the committee who made the arrangements. The Council also direct the attention of the members to the great courtesy shown by the Whitehaven Collieries Company, the Postlethwaites Eskett Mining Company, the Cleator Iron-ore Company, the Winder Gill Iron-ore Company, the St. Helens Colliery and Brickworks Company, and the Greenside Mining Company, and have great pleasure in recording the thanks of the Institute to all who by their services contributed to the holding of that successful meeting.

FINANCE REPORT.

The ordinary income for the year 1893-94 amounted to £1,898 4s. 7d., being an increase over the previous year of £86 10s. 4d.

The total receipts from subscriptions and arrears, excluding amounts paid in advance, amounted to £1,567 9s., an increase of £106 18s. over the preceding year.

The amount of subscriptions now in arrear, after striking off those which are considered irrecoverable and excluding the current year, is £29 8s.

The total expenditure amounted to £1,909 16s. 8d., an increase of £177 1s. 2d. The exceptional items contributing to this increase are: Contributions to The Federated Institution of Mining Engineers, owing to the increased number of members, £55 14s. 5d.; electric light fittings in the Wood Memorial Hall and Lecture Theatre, £57; book-shelves in the corridor adjoining the Lecture Theatre, £87 4s.; and an increase on account of postages of £12 0s. 3d., due to the increased number of members. There has, however, been a decrease of £29 1s. 4d. in the expenditure on books for the library, and of £18 18s. on the amount awarded for prizes, owing to last year's balance sheet, including the prizes awarded for two years.

The CHAIRMAN proposed the adoption of the Reports of the Council and of the Finance Committee.

Mr. THOMAS DOUGLAS seconded the resolution.

The resolution was then agreed to.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

FOR THE YEAR ENDING

	£ s. d.	£ s. d.
July 22nd, 1893.		
To Balance at Bankers	468 3 8	
„ „ in Treasurer's hands	84 12 3	
„ Outstanding Amounts for Authors' Excerpts	11 15 4	
		564 11 3
„ Dividend of 7½ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for the year ending June, 1894	201 0 0	
„ Interest on Investments with the River Tyne Commissioners	53 8 0	
		254 8 0
To SUBSCRIPTIONS FOR 1893-94 AS FOLLOWS:—		
466 Members ... ... @ £2 2s.	978 12 0	
33 Associate Members ... ... @ £2 2s.	69 6 0	
41 Associates ... ... @ £1 1s.	43 1 0	
26 Students ... ... @ £1 1s.	27 6 0	
87 New Members ... ... @ £2 2s.	182 14 0	
1 New Member	25 0 0	
10 New Associate Members ... ... @ £2 2s.	21 0 0	
15 New Associates ... ... @ £1 1s.	15 15 0	
5 New Students ... ... @ £1 1s.	5 5 0	
	1,367 19 0	
To SUBSCRIBING COLLIERIES, VIZ.:—		
Ashington Coal Company £2 2 0		
Birtley Iron Company 6 6 0		
Bridgewater Trustees 6 6 0		
Marquis of Bute 2 2 0		
Butterknowle Colliery Company ... 2 2 0		
Cowpen Coal Company 4 4 0		
Earl of Durham 10 10 0		
Elswick Coal Company 2 2 0		
Haswell Coal Company 4 4 0		
Hetton Coal Company 10 10 0		
Hutton Henry Coal Company 2 2 0		
Marquess of Londonderry 10 10 0		
North Brancepeth Coal Company ... 2 2 0		
North Hetton Coal Company 6 6 0		
Ryhope Coal Company 4 4 0		
Seghill Coal Company 2 2 0		
South Hetton Coal Company 4 4 0		
Stella Coal Company 2 2 0		
Throckley Coal Company 2 2 0		
Victoria Garesfield 2 2 0		
Wearmouth Coal Company 4 4 0		
Westport Coal Company 4 4 0		
	96 12 0	
To Donations	4 4 0	
	1,468 15 0	
Less—Subscriptions for current year paid in advance last year	57 15 0	
	1,411 0 0	
To Arrears received	156 9 0	
	1,567 9 0	
„ Subscriptions paid in advance during current year ...	56 14 0	
		1,624 3 0
„ Sale of Publications		19 13 7
		£2,462 15 10

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.
JULY 31ST, 1894.

July 21st, 1894.	£	s.	d.	£	s.	d.
By Printing and Stationery				160	2	7
„ Books for Library	44	19	11			
„ Prizes for Papers	17	17	0			
„ Incidental Expenses	54	1	10			
„ Postages	57	5	5			
„ Sundry Accounts	16	17	6			
„ Travelling Expenses	7	6	1			
„ Salaries	150	0	0			
„ Clerks' Wages	152	7	4			
„ Reporter's Salary	12	12	0			
„ Rent	93	7	2			
„ Rates and Taxes	22	2	10			
„ Insurance	12	8	4			
„ Furnishing, Repairs, etc.	107	19	3			
„ Coals, Gas, Electric Light, and Water	21	3	1			
„ Electric Light and Fittings, etc.	57	0	0			
				827	7	9
„ Fan Committee	1	14	9			
„ Explosives Committee	81	16	1			
„ British Association Meeting—Delegate's Expenses ...	6	17	0			
				90	7	10
By Federated Institution of Mining Engineers—Subscriptions	847	10	3			
Less—Amounts paid by Authors for Excerpts ...	15	11	9			
				831	18	6
				1,909	16	8
By Balance at Bank	457	10	0			
„ „ in Treasurer's hands	84	12	3			
„ Outstanding Amounts for Authors' Copies	10	16	11			
				552	19	2

I have examined the above account with the Books and Vouchers relating thereto, and certify that, in my opinion, it is correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 3rd, 1894.

£2,462 15 10

DR. THE TREASURER IN ACCOUNT

			£ s. d.	£ s. d.
To 565 Members, 24 of whom are Life Members.				
541	541	@ £2 2s.		1,136 2 0
To 47 Associate Members, 5 of whom are Life Members.				
42	42	@ £2 2s.		88 4 0
To 47 Associates		@ £1 1s.		49 7 0
To 34 Students, 1 transferred to list of Members.				
33	33	@ £1 1s.		34 13 0
To 22 Subscribing Collieries		... ...		96 12 0
To 87 New Members		@ £2 2s.		182 14 0
To 1 New Member		@ £25		25 0 0
To 10 New Associate Members		@ £2 2s.		21 0 0
To 15 New Associates		@ £1 1s.		15 15 0
To 5 New Students		@ £1 1s.		5 5 0
To Donations				4 4 0
				1,658 16 0
To Arrears, as per Balance Sheet 1892-93			220 10 0	
Add—Arrears considered irrecoverable, but since received			10 10 0	
			231 0 0	
Less—Struck off as irrecoverable. Arrears		£45 3 0		
" " " Current year		27 6 0		
			72 9 0	
				158 11 0
				1,817 7 0
To Subscriptions Paid in Advance				56 14 0
				£1,874 1 0

WITH SUBSCRIPTIONS, 1893-94. CR.

	PAID. £ s. d.	UNPAID. £ s. d.
By 466 Members, paid ... ... @ £2 2s.	978 12 0	.....
By 74 „ unpaid ... ... @ £2 2s.	.....	155 8 0
By 1 „ dead ... ... @ £2 2s.	.....	2 2 0
541		
By 33 Associate Members, paid ... ... @ £2 2s.	69 6 0	.....
By 8 „ „ unpaid ... ... @ £2 2s.	.....	16 16 0
By 1 „ „ dead ... ... @ £2 2s.	.....	2 2 0
42		
By 41 Associates, paid ... ... @ £1 1s.	43 1 0	.....
By 6 „ unpaid ... ... @ £1 1s.	.....	6 6 0
47		
By 26 Students, paid ... ... @ £1 1s.	27 6 0	.....
By 7 „ unpaid ... ... @ £1 1s.	.....	7 7 0
33		
By 22 Subscribing Collieries, paid	96 12 0	.....
By 87 New Members, paid ... ... @ £2 2s.	182 14 0	.....
By 1 New Member, paid ... ... @ £25	25 0 0	.....
By 10 New Associate Members, paid ... ... @ £2 2s.	21 0 0	.....
By 15 New Associates, paid ... ... @ £1 1s.	15 15 0	.....
By 5 New Students, paid ... ... @ £1 1s.	5 5 0	.....
By Donations	4 4 0	.....
	1,468 15 0	190 1 0
Less struck off as irrecoverable	.....	27 6 0
		162 15 0
By Arrears, paid	156 9 0	.....
„ „ unpaid	.....	29 8 0
By Subscriptions paid in advance	56 14 0	.....
	1,681 18 0	192 3 0
		1,681 18 0
		£1,874 1 0

General Statement, July 21st, 1894.

Liabilities.	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	56	14	0			
,, carried over from previous year	2	2	0			
				58	16	0
Capital				9,380	7	8
				£9,439	3	8

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Bonds have been produced to me.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
August 3rd, 1894.

Assets.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	457	10	0			
,, in Treasurer's hands	84	12	3			
Outstanding amounts for Authors' Excerpts ...	10	16	11			
				552	19	2
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd.	.....			2,680	0	0
Invested with River Tyne Commissioners ...	.....			1,500	0	0
Arrears of Subscriptions	.....			192	3	0
Value of 541 Bound Volumes of Transactions, @ 8s. 6d.	229	18	6			
,, 4,398 do., @ 6s....	1,319	8	0			
,, 2,565 Unbound Parts, @ 1s.	128	5	0			
,, 77 Copies of Mr. T. F. Brown's Map, @ 2s. 6d.	9	12	6			
,, 372 Copies of Index, Vols. 1-25, @ 1s.	18	12	0			
,, 848 Copies of Catalogue of Fossil, Plants, @ 2s. 6d.	106	0	0			
,, 752 Copies of Fossil Illustrations, @ 5s.	188	0	0			
,, 1,500 Copies of Borings and Sinkings (Vol. I. in Sheets) @ 1s.	75	0	0			
,, 270 Do., Vol. I., @ 2s. 6d.... ...	33	15	0			
,, 301 Do., Vol. II., @ 2s. 6d.... ...	37	12	6			
,, 314 Do., Vol. III., @ 2s. 6d.... ...	39	5	0			
,, 420 Do., Vol. IV., @ 2s. 6d.... ...	52	10	0			
,, 370 Do., Vol. V., @ 2s. 6d.... ...	46	5	0			
,, 254 Copies of Library Catalogue, @ 1s.	12	14	0			
,, 308 Copies of French Commission Report on Explosives in parts, @ 1s. ...	15	8	0			
,, 9 Do., Bound, @ 4s.	1	16	0			
				2,314	1	6
,, Office Furniture and Fittings ...	450	0	0			
,, Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£9,439	3	8

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

Mr. Thomas Douglas moved that the following gentlemen be elected as the representatives of this Institute on the Council of The Federated Institution of Mining Engineers for the ensuing year:—

Mr. E. Bainbridge.
Mr. T. W. Benson.
Mr. Thos. J. Bewick.
Mr. W. C. Blackett.
Mr. T. Forster Brown.
Mr. Wm. Cochrane.
Mr. Jno. Daglish.
Mr. G. B. Forster.
Mr. T. E. Forster.
Mr. Jeremiah Head.
Mr. Henry Lawrence.
Mr. C. C. Leach.
Sir Wm. Thos. Lewis.
Mr. Geo. May.
Mr. H. Palmer.
Mr. M. W. Parrington.
Mr. T. O. Robson.
Mr. J. B. Simpson.
Mr. A. L. Steavenson.
Mr. T. Wrightson.
Mr. Lindsay Wood.
Mr. W. O. Wood.

Mr. B. McLaren seconded the resolution, which was unanimously agreed to.

Mr. J. T. Todd moved that a vote of thanks be accorded to those gentlemen who had represented the Institute on the Council of The Federated Institution of Mining Engineers during the past year.

The Chairman seconded the resolution, which was cordially agreed to.

ALTERATION OF BYE-LAW 17.

The Chairman moved that Bye-law 17 be amended as follows:—

17. Any Member, Associate Member, Associate or Student may, at any time, compound for all future subscriptions by a payment in accordance with the following scale:—

Under 30 years of age, the sum of				£27
Over 30	,,	,,	,,	24
,, 40	,,	,,	,,	21
,, 50	,,	,,	,,	18
,, 60	,,	,,	,,	14

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

Mr. Thomas Douglas seconded the resolution, which was unanimously adopted.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. R. HAY ANDERSON, Mining Engineer and Mine Manager, La Compañia Unida Mejicana de Minas, Guanajuato, Mexico.

Mr. HARRY ASHCROFT, Assistant Manager, Borrea Coal Co., Limited, Seetarampore, Bengal, India.

Mr. WILLIAM HENRY BORLASE, Mines Manager and Engineer, Brown How, Ullesswater, Glenridding, near Penrith.

Mr. IAN CAMERON, Mining Engineer, Sudbury, Ontario, Canada.

Mr. JAMES WILCOCKS CARRALL, Mining Engineer and Acting Commissioner of the Amoy Customs, Amoy, China.

Mr. HORATIO COLLINS, Manager of the Woodbush Gold Mining Co., Limited, Haenertsburg, Transvaal.

Mr. S. T. CROASDELL, Mechanical Engineer, Lowca Engineworks, Whitehaven.

Mr. GEORGE MATTHEW DARBY, General Manager of the Katrass Kerria Coal Co., Limited, Katrass P.O., *via* Barrakar, Bengal, India.

Mr. W. H. FURLONGE, Mining Engineer, c/o Messrs. Proctor Bros., Antananarivo, Madagascar.

Mr. STRANGEMAN HANCOCK, Mining Engineer, Rand Club, Johannesburg, Transvaal.

Mr. GUY ROCHE JOHNSON, Mining and Civil Engineer, Longdale, Alleghany Co., Virginia, U.S.A.

Mr. ROBERT KAY, Colliery Manager, South Tanfield, Stanley, R.S.O., Co. Durham.

Mr. JAS. MACNAB, Engineer, 17, Bolsover Street, Portland Place, London, W.

Mr. J. M. MAIN, Mining Engineer, Keekle House, Cleator Moor, *via* Carnforth.

Mr. JAMES MILLER, Chemist and Metallurgist, The Mexican Gold and Silver Recovery Co., P.O. Box 121, Mexico City, Republic of Mexico.

Mr. RALPH PATTERSON WILLIAM OSWALD, H.M. Inspector of Mines, 10, Rosebank, Whitehaven.

Mr. JOSEPH PROVIS, Lecturer on Mining, Metallurgy, and Technical Engineering, School of Mines, Kapunda, South Australia.

Mr. BEVERLEY S. RANDOLPH, Civil and Mining Engineer, Frostburg, Maryland, U.S.A.

Mr. WILLIAM REDSHAW, Colliery Manager, Whitehaven Colliery Office, Whitehaven.

Mr. WILLIAM SCHROLLER, Engineer and Contractor, 13, Old Elvet, Durham.

Mr. ELGIN SCOTT, Manager, Ropienka Oil-Wells, Ropienka, Galicia, Austria.

Mr. ARTHUR WHITCOMB SHEAFER, Mining Engineer and Geologist, Pottsville, Pennsylvania, U.S.A.

Mr. EDWARD THOMAS, Mine Surveyor, Mines Department, Sydney, New South Wales.

Mr. EDWARD WATSON, Colliery Manager, Redheugh Colliery, Gateshead.

Mr. C. L. WAUGH, Colliery Manager, Buckhill Collieries, Great Broughton, Cumberland.

ASSOCIATE MEMBERS—

Mr. ARTHUR D. CARR, Land Agent, Whickham Rectory, Whickham, R.S.O.

Mr. A. E. W. Gwyn, Agent of the Ingersoll-Sergeant Drill Co., 114A, Queen Victoria Street, London, E.C.

Mr. H. R. Hancock, Moonta Mines, South Australia.

Mr. George C. Hooper, Surveyor of Mines, Whitehaven Collieries, Whitehaven.

Mr. Stephen Humble, Jun., Engineer, 9, Victoria Street, Westminster, London, S.W.

Mr. Reiji Kanda, Mining Engineer, c/o Mr. Takahira Kanda, 9, Awajicho-Nichome, Kanda, Tokio, Japan.

Mr. C. Ochiltree Macdonald, Editor of the *Canadian Colliery Guardian*, 161, Hollis Street, Halifax, Nova Scotia.

Mr. Frank L. Nason, 5, Union Street, New Brunswick, New Jersey.

Mr. Frederick Danvers Power, c/o Messrs. Henderson & Macfarlane, 2, Bridge Street, Sydney, New South Wales.

Mr. Umfreville Percy Swinburne, Salisbury, Mashonaland, South Africa.

Students—

Mr. Cecil Alfred Burne, Mining Student, Cornsay Colliery Office, near Durham.

Mr. John Ridley Hetherington, Mining Student, Cornsay Colliery Office, near Durham.

Mr. William Jones, Mining Student, Trimdon Grange Colliery, Trimdon Grange, R.S.O.

Mr. Herbert William Middleton, Mining Student, Trimdon Grange Colliery, Trimdon Grange, R.S.O.

Mr. John William Peel, Mining Student, Coundon, Bishop Auckland.

The following gentlemen were nominated for election :—

Members—

Mr. William Henry Angove, Engineer, Albany, Western Australia.

Mr. James Ford Davison, Mining Engineer, Yarlside, Barrow-in-Furness.

Mr. Jonathan Dixon, Colliery Manager, Homeville, West Maitland, New South Wales.

Mr. John Thomas Foulis, Mine Agent, 42, Demesne Road, Douglas, Isle of Man.

Mr. George C. Hooper, Surveyor of Mines, Whitehaven Collieries, Whitehaven.

Mr. Henry Thornton Newbigin, Engineer and Manager, c/o Messrs. M. Coulson & Co., Spennymoor.

Mr. Horace Pratt, Colliery Manager, Jobs Hill, Crook.

Mr. James Russell, Mine Manager, etc., Ukalunda, via Bowen, Queensland.

Mr. Charles Turner Saner, General Manager, Van Ryn Estate and Gold Mining Co., Limited, P.O. Box 357, Johannesburg, Transvaal.

Mr. George A. Spotswood, Mining Engineer, 46, Clarence Street, Kingston, Ontario, Canada.

Mr. Thomas Pressick Yeoman, Mining Engineer, Bengal Coal Co., Giridih, Bengal, India.

ASSOCIATE MEMBERS—

Mr. BENJAMIN ROBINSON BANYER, Mining Student, School of Mines, Kapunda, South Australia.

Mr. EDWARD ECCLES, King Street, Newcastle-upon-Tyne.

Mr. RICHARD JOHN MIDDLETON, Manager of the *Mining Journal*, 18, Finch Lane, London, E.C., and The Lilies, Balfour Road, Highbury New Park, London, N.

Mr. B. J. TOWNSEND, Toronto, Ontario, Canada.

Mr. ARTHUR WATSON, Mining Student, Hamsterley Colliery, Ebchester, Co. Durham.

Mr. JOHN WEATHERBURN, Draughtsman, 53, Cuthbert Street, Gateshead.

ASSOCIATES—

Mr. THOMAS BATTEY, Overman, Percy Terrace, Backworth Colliery.

Mr. WILLIAM RALPH BELL, Assistant Under-manager, Wearmouth Colliery, Sunderland.

Mr. JOSEPH STANLEY COWELL, Assistant Under-manager, Wearmouth Colliery, Sunderland.

Mr. THOMAS PROCTOR, Overman, Ashington Colliery, Northumberland.

Mr. JOS. C. SOUTHERN, Master Wasteman, Harraton Colliery, Washington, R.S.O., Co. Durham.

STUDENTS—

Mr. EDWARD HERBERT CLIFFORD, Mining Student, 24, Gledstanes Road, West Kensington, London, S.W.

Mr. MICHAEL FALCON, Mining Student, Thwaites Parsonage, Millom, Carnforth.

Mr. JAMES ARTHUR IMESON, Articled Apprentice, Wearmouth Colliery, Sunderland.

Mr. ERNEST MCGOWAN, Articled Apprentice, Wearmouth Colliery, Sunderland.

Mr. H. G. RAEBURN, Mining Student, Redheugh Colliery, Gateshead.

Mr. FRANK COULSON read the following paper on "Sinking with Rock-drills":—

SINKING WITH ROCK-DRILLS.

By FRANK COULSON.

In the following paper, unless otherwise stated, it is understood that reference is made to a shaft 18 feet in diameter when finished.

In deciding the form of a shaft, the author fails to understand, why in some districts oblong shafts are sunk in preference to round ones, unless the object be to take out as little ground as possible. It seems desirable, in order to wind a given quantity of work, that there should be the same area (over and above the space occupied by the cages at meetings) in the one as in the other shaft, to admit of adequate ventilation. This consideration is in fact so important, that in many instances it is deemed desirable to sink a staple for a height of some 120 feet, having a holing into the shaft above and below meetings, so that the area for ventilation may not be diminished when the cages are passing each other.

An oblong shaft with the same area as one 18 feet in diameter should be about 24 feet long and 10 feet wide.

The following are some objections to an oblong as compared with a round shaft :—

(*a*) The cost of sinking is enhanced, owing to the difficulty of squaring out the corners.

(*b*) The cost of lining is more :—An oblong shaft lined with timber costs £2 5s. per foot ; a round shaft lined with bricks at 20s. per 1,000 costs £1 4s. 2d. per foot.

(*c*) It is more difficult to shut off water in a square shaft.

(*d*) The difficulty of placing the shaft in the most suitable situation, having regard to surface and underground arrangements, the position of railway-sidings, and other considerations. The author is of opinion that it is desirable, not to say essential, that the greatest length of an oblong shaft should be across the cleat of the stone, so that the long side may be in the position most easily supported.

(*e*) When sinking through the leader of a trouble, running as shown in Figs. 1 and 2 (Plate I.), across the narrow width of the shaft, the danger to the men and the cost of securing the sides of the shaft is enormously increased in the case of the oblong shaft. It will be readily

recognized that the mass of stone shown in Fig. 1 at A, and weighing about 120 tons will be very liable to fall, especially if the weight of the leader about 250 tons, be added. Further, after the leader of the trouble is passed through, and has left the shaft, if the beds rise towards the leader, there will also be a quantity of stone under the leader very difficult to support; this is shown at B in Fig. 1.

(*f*) The timber-lining will not last so long as brickwork, and seeing that the shaft is the one entrance into the mine through which all the men must pass in going and coming from their work, it is desirable that it should be made as safe as possible by being securely lined throughout. Some of the rock met with near the surface may be left unlined, but after a few years such places require frequent attention.

In order to obtain the greatest advantage from the use of rock-drills in sinking or tunnelling, it is necessary that a given length be driven by each series of holes, and that all the holes of such a series should be fired simultaneously, either by electricity or by a quick-running fuze, but there is some danger in using the latter. Not only where rock-drills are used, but where the holes are drilled by hand, much better results are obtained in all cases by firing all the holes at once by electricity.

It is essential for speed in sinking to get one or more rock-drills into the bottom of the shaft as soon as a clear place can be made ready after blasting, and it is the especial duty of the chargeman to concentrate the labour on that part of the pit-bottom which can soonest be got ready for the machines. By this means three or four holes (sometimes more) can be drilled before the whole of the stones have been filled away. The whole of the drilling for the next length is then completed before the machines are taken out of the pit.

The number, position, and depth of the holes to be drilled in the bottom of the pit for each round naturally varies according to the nature of the rock being passed through.

In hard limestone or very hard sandstone, as the Pennant rock of South Wales, there should be about nine sumping-holes about $4\frac{1}{2}$ feet deep and from twenty to twenty-two canch-holes round the sides, each about 4 feet deep (Figs. 3, 4, 5, and 6, Plate I.) In ordinary sandstone, probably nine sumping-holes 6 feet deep, and from eleven to thirteen canch-holes 5 feet deep, will be sufficient. In shale or mild sandstone, nine sumping-holes drilled to a depth of about $6\frac{1}{2}$ feet, will clear out 6 feet of stone, leaving the sides perfectly perpendicular, or at most requiring two or three

additional short canch-holes, which are put in by hand during the time that the loose stones are being sent out of the pit.

Where both sumping and canch-holes are drilled, the sumping-holes are fired first, an iron rod, with a loop on the top, being put into each canch-hole to prevent them from being filled up by the loose stones from the shots. While the workmen are filling away the stones from the sumping-holes, the canch-holes are being charged, and are fired at the most suitable opportunity. Where no canch-holes are required, all the sumping-holes are fired together.

The work of drilling can be occasionally expedited by leaving some of the holes short, as bored by the rock-drills, and finishing them by hand-jumpers.

The depth sunk by each round of holes, according to the methods herein described, is :—

	Feet.		Hours.
Hard limestone	4½	in	18
Hard sandstone	5½	„	18
Shale and sandstone	6½	„	16

The average quantity of gelignite used is as under :—

	Lbs.	
In hard stone, for a length of 4½ to 5 feet—		
Nine sumping-holes 3 lbs. each	27	
Twenty canch-holes, ¾ lb. each	15	
Total		42
In mild stone, for a length of 6 feet—		
Nine sumping-holes 3½ lbs. each	32	
Eight canch-holes ¾ lb. each	6	
Total		38

These quantities may seem excessive, the aim, however, is not only to lift the stone, but to break it up and make it easy for the workmen to fill without having to break it with hammers.

It may be suggested that the position of the canch-holes, as described, might be liable to damage the sides of the shaft, but this damage is not likely to occur in practice.

The weight of stone lifted with each round of shots averages :—

	Tons.
For hard stone	130
For mild stone	155

It is no uncommon experience for three men to drill six holes with two machine-drills during the time that twelve men are drilling four holes by hand: the special advantage in favour of the use of rock-drills in hard stone being that the same work is effected in about half the time.

The following average results per week have been obtained with the rates of wages now prevailing (May, 1894):—

	Depth Sunk.	Cost per yard.								
		Wages.			Explosives.			Total.		
	Feet.	£	s.	d.	£	s.	d.	£	s.	d.
Very hard limestone, without partings	30	10	4	9	1	18	0	12	2	9
Coal-measure shales and sandstones ...	39	7	12	6	0	19	0	8	11	6

The plant required for the work is as follows:—

An air-compressor having an air-cylinder, 16 inches in diameter by 24 inches stroke, with a 20 nominal horse-power boiler attached. Each drill when working will require about 30 lbs. of coal per hour, working at most four hours per day, and the consumption for four drills will be 480 lbs.

Where it is possible to obtain the steam for the air-compressor from the boilers supplying the winding-engine, the cost for steam is greatly reduced, and by placing the air-compressor near the top of the shaft, so that the assistant banksmen may attend to it, there is a further saving in the cost of labour.

Four rock-drills as under:—Two drills with cylinders, $3\frac{1}{2}$ inches in diameter, capable of drilling a hole 7 to 8 feet deep, and finishing with a diameter of $2\frac{1}{4}$ inches at the bottom; two drills having cylinders 3 inches in diameter, capable of drilling a hole 6 feet deep and $1\frac{1}{2}$ inches in diameter at the bottom.

Percussive rock-drills with a long stroke, having an automatic rotating arrangement and a screw worked by hand for turning them down as the hole progresses, are found most suitable for the work. Rotary drilling-engines, both with twist-steel drills and diamond drills, have been tried with only moderate success. The drilling-engine with the twist drills was perhaps the most suitable of the two, but owing to the frequency with which bands of ironstone and hard sandstone were met with, which the drills will not touch, their use was abandoned. Diamond boring-machines were found to be too slow.

The pipe required for conveying the compressed air down the shaft to drive four drills should be $2\frac{1}{2}$ inches in internal diameter and of light wrought-iron, the drills being connected to the bottom of the pipe by flexible tubes $\frac{3}{4}$ or 1 inch in diameter and from 30 to 36 feet long, having an instantaneous coupling to attach them to the wrought-iron pipe.

A heavy circular iron frame with screws to set out against the side of the shaft to keep it steady—hanging on two ropes—worked by a crab-engine, having two drums capable of being worked together or separately, appears to be the best arrangement for carrying rock-drills

in a pit-bottom, but it is found very difficult to keep such an arrangement from rocking when all the drills are running. A frame of this description—by being somewhat less on the outside diameter than the diameter of the walling—could be readily used as a scaffold for walling or other purposes. There is, however, no difficulty in working the machine-drills on ordinary tripod-stands: in fact, taking into consideration the slips which are met with in the stone, probably the holes can be put in to a greater advantage when using tripod-stands than by any other means. In an oblong shaft the rock-drills are put on stretcher-bars, and all the drilling is completed before they are taken out, except the holes in the corners, which are generally drilled by hand. The holes are then fired in four series, the first fired being five or six holes out of the middle of the pit.

There are many kinds of steel bits used for rock-drills, but some of the best are shown in Figs. 7, 8, 9, and 10 (Plate I.). In all cases it is desirable to use as simple a bit as possible so as to save blacksmith's work.

For hard stone, + or X bits (Figs. 7 and 8) are most suitable. For sandstone, bits with a broad edge, not sharpened (Fig. 9), and for soft ground, bits as shown in Fig. 10 are most suitable.

The + bit is more easily sharpened than the X bit, but will not bore in places where the work can be done by the latter, whereas the X bit will bore under all circumstances where work can be done by the + bit. The bit shown in Fig. 10 bores more rapidly: having a piece cut out of the sides, it keeps the hole round, and prevents canches from being formed. It is the best all-round drill, except for very hard stone.

There are two modes of firing by electricity, *i.e.*, by high-tension or low-tension fuzes. Low-tension fuzes are perhaps more liable to go wrong, or to fail in manufacturing, owing to the extreme fineness of the platinum wire used. Notwithstanding this defect they seem preferable for use, particularly in mining work, where it is essential that there shall be no missed shots. Each fuze can be tested before being sent down the pit, and when all the holes are charged and the connexions made, the whole blast can be re-tested before firing, care being taken to have the men out of danger before the test is applied, lest any fuze more sensitive than its fellows should explode during the test. It is essential that the cables should be tested as soon as the shots have been fired, so that they can be repaired if necessary before being again required; that each piece of connecting

wire, old and new, should be tested before putting them ready to send down the pit, and that each fuze should be tested although the latter are tested and guaranteed before being sent from the manufactory, and again that the blast should be tested after all connexions are made. The cables used are good copper wire, No. 7 wire-gauge, well insulated and braided, and in no case should both wires be in one cable, but they should be entirely separate, and placed 2 or 3 feet apart in the pit. The author's experience with two wires in one cable has been most unsatisfactory. It is also essential that the cables should be kept as dry as possible.

The copper wire used for connecting the shots in the pit-bottom is No. 14 wire-gauge, insulated with a thin covering of guttapercha at a cost of about 60s. per mile, and most of the wire can be used several times over.

The fuzes, cables, etc., are tested by passing a slight current of electricity through them attached to a galvanometer: the needle should move to one place on the dial if the fuzes are right.

The advantages claimed for the electrical system of shot-firing are :— (*a*) The greater despatch and cheapness with which work can be done. (*b*) The greater safety of the men, there being less chance of missed-shots, and no chance of a shot hanging fire. (*c*) The absence of smoke after the shots are fired.

Black powder is the cheapest explosive for use in dry work, but taking into consideration the extra labour entailed in making ready the holes, a high and powerful explosive is usually found more economical, the charge does not occupy so great a length of the hole, the full force is exerted at the bottom of the hole, with less risk of leaving sockets, as in the case of black powder ; this is important, as it is desirable to have the pit-bottom as level as possible for the machines.

The two methods of shutting-off water in shafts most generally used are by cast-iron tubbing and walling built of brick and cement. The following costs have recently been given of the respective modes, which appear to have been allowed to go uncontradicted :—

	Per Foot. £
Tubbing...	26
Brickwork	18
Cement	8

Very much depends, of course, upon what items are included in the cost, and the pressure of water, but taking it in all cases that the cost of sinking is the same it may be supposed that it is not included in the prices given.

In several long lengths of water-tight walling, extending for something over 240 feet, the cost of the walling, where it was thickest, that is at the bottom, was £6 6s. 8d. per vertical foot, including the cost of labour and material and the extra cost over and above the price of sinking for making the shaft sufficiently large to admit of the extra thickness of walling (probably $3\frac{1}{2}$ feet larger in diameter than is necessary for tubbing). This price seems to compare very favourably with the prices above named. The cost price for tubbing this length would have been about £12 per foot.

The walling was put in as shown in Figs. 11 and 12 (Plate I.), that is, the walling was built about 3 feet at a time of $4\frac{1}{2}$ inches brickwork, in front of which were placed sheet-iron plates 14 to 16 wire gauge. In front of this there was brickwork about 20 inches thick, leaving a space of $1\frac{1}{2}$ inches between the inner and outer walls to be filled in with cement, in which the iron plates were embedded. As the pressure of water became less, the thickness of the front wall was gradually decreased from 20 to 15 inches and from 15 to 10 inches, the space for cement being kept in one continuous length. The best results were obtained when the water in the pit was allowed to follow the work, so that the cement set under water, but this is not in all cases possible.

The walling consisted of a good class of shale-brick of the ordinary building size, set in cement. It is preferable to put a short length of solid work in at the bottom under the water-bearing strata where possible, and to convey the water through it in pipes, as shown in Fig. 11. It is generally found, when the water is plugged off, that a considerable quantity percolates through the bricks for a few days, but as a rule it gradually takes off and the walling then becomes quite dry.

Attempts have been made to carry on the sinking and walling of shafts at the same time by use of the Galloway stage, but the result was not all that could be desired. As the stage gradually goes up and the sinking goes down, the stage gets a long way out of the bottom of the shaft, necessitating the loss of considerable time and the use of great care in steadying the tub. Where a stage is used and kept near the bottom, with the tub running in guides, the work can be most quickly got out, as the tub requires very little steadying, and it is a great convenience having the stage available, so placed that men can go to any part of the shaft at a moment's notice. It also affords some protection to the men in case of anything falling into the pit.

The pneumatic water-tub is an arrangement intended to replace the bowling of water and to enable sinking to be carried on under circumstances which would otherwise necessitate the use of pumps.

The original idea was to obtain a vacuum by filling the water-tub with steam in the pit-bottom and allowing it to condense. This was found to be too slow, and was improved upon by means of an air-pump on the surface pumping out of an old boiler; pipes were taken from the vacuum chamber to the bottom of the shaft, and attached to the water-barrel by means of a flexible tube having an instantaneous coupling.

As soon as the tub arrives in the bottom of the shaft the connexion is made, and a valve on the end of the flexible tube opened; the air is then exhausted from the water-tub, and the water rises through the bottom valve, filling a 600 gallons tub in about thirty seconds. 100 gallons of water per minute can be lifted by this means with a fair amount of satisfaction, but as soon as that quantity is exceeded, it is advisable to have pumps, notwithstanding the temptation there is to continue with a tub as long as possible.

The best results in sinking are obtained with the old lift-sinking set of pumps—hanging on ground-spears—worked by an engine on the surface: this allows the sinking to be carried on without interruption of work, caused by the pumps being damaged by shots.

Damage to the bottom-pieces of pumps—that is the snore-piece of a lift-sinking set, which frequently occurs from the shock, where high explosives are used—is always a source of trouble and delay; but it can be avoided by keeping the pumps 3 or 4 inches off the bottom when the shots are fired. Where the pumps and pumping-engine are suspended in the shaft, as in the case of the Worthington pump, and pumps of that type, it is advantageous to have all the connexions of the steam, exhaust, suction, and rising-main pipes, where they join the engine, made with a short length of flexible tubing.

The Chairman said that this paper was a very useful and practical one. The members who attended the recent Whitehaven meeting would notice that most of the shafts in that district were of oblong shape. In bad ground it was almost impossible to make the shafts rectangular; and for this reason, no doubt, the round shaft would be most generally preferred. Mr. Coulson said that—

In order to obtain the greatest advantage from the use of rock-drills in sinking or tunnelling, it is necessary that a given length be driven by each series of holes, and that all the holes of such a series should be fired simultaneously, either by electricity or by a quick-running fuze, but there is some danger in using the latter. Not only where rock-drills are used, but where the holes are drilled by hand, much better results are obtained in all cases by firing all the holes at once by electricity.

He agreed that it was desirable to lift the stone by simultaneous shots if possible. He had tried to utilize this method in the Cleveland ironstone-mines; but the trials were not successful, as the ironstone required a slow explosive. He would like to ask Mr. Coulson if he had ever found a dangerous atmosphere after shot-firing in a shaft? He agreed with Mr. Coulson that in hard stone the percussive rock-drill was the best, but he was still hoping to find some means of getting over the difficulty of using a rotary drill in hard stone. He (the Chairman) thought it was not possible to drill a deep hole with percussive drills without water; and they would be glad to know whether water was used by Mr. Coulson, or whether he worked dry?

Mr. W. C. Blackett asked Mr. Coulson if he had experienced any difficulty in winter in shafts tubbed with brick by the frost frittering away the sides of the shaft?

Mr. Thomas Douglas asked whether Mr. Coulson's experience in the matter of firing shots simultaneously enabled him to say whether he had attained that object? He concluded that there had been no difficulty from the fumes or smoke arising from the firing of the shots, although he would have thought it probable?

Mr. F. Coulson said he had never had any trouble with fumes except in the case of one or two experimental trials of different explosives, whose ignitions had not been complete. In one case, 34 holes had been fired at once; and the men went back within one minute after the shots had been fired, and there were no fumes whatever. Water was used in drilling the holes, but in a dry pit the small quantity used could be sent down in pails, no regular supply of water being necessary. He had not found any case of bricks frittering away as suggested by Mr. Blackett, although he had found broken bricks. He had never known any walling to give way from this cause, except in old shafts where it had occurred, to a certain extent. He had put in five lengths of water-tight cement walling varying from 180 to 250 feet in length.

The Chairman proposed a vote of thanks to the writer of the paper.

Mr. W. O. Wood, in seconding the resolution, said that the paper was valuable, bearing, as it did, upon a subject which seldom came within the scope and experience of mining engineers in this district, where all the pits required were sunk.

Mr. R. W. Moore read the following paper on "Improvements in Brick-kilns":—

IMPROVEMENTS IN BRICK-KILNS.

By R. W. MOORE.

In an ordinary brick-kiln, the products of the combustion of the coal used in the process of burning are allowed, after circulating amongst the charge, to escape direct to the chimney without further utilization, and as the combustion is imperfect, resembling more or less destructive distillation, a large proportion of the volatile products passes unconsumed up the chimney, and is consequently wasted.

Another disadvantage of using the old type of kiln is that excessive firing, entailing an unnecessarily large consumption of fuel and a considerable waste of time, is absolutely requisite to ensure that the whole of the contents are burnt; and thus the front part of the charge, that nearest the fire, is discoloured, whilst the material at the back is frequently underburnt. A further disadvantage that the old kiln possesses is the difficulty of ascertaining when the moisture is driven off the stack of raw material and when the full heat may be applied.

These disadvantages have been got rid of by the improvements which form the subject of letters patent (No. 3,343, 1890), which have been applied with marked advantage by the Seaton Firebrick Company to their kilns at Moorhouse Guards.

These improvements in the construction of brick kilns consist in conveying what was hitherto waste gas (the result of the imperfect combustion of the coal consumed in the space left between the charge and the front of the kiln), after it passes through the interstices of the charge, into a combustion-chamber, shaped like a beehive, built at the back of the kiln, by means of three flues, as shown in Figs. 1, 2, and 3 (Plate II.). Fig. 4 shows the application of the improved system to an old kiln.

Two plugs or valves admit a small proportion of air into the top and bottom of the combustion-chamber, thereby raising the ignited gaseous mixture to a white heat, and bringing the brickwork intervening between the combustion-chamber and the kiln into an incandescent state. This intense heat at the rear of the kiln ensures that the charge is burnt as well at the back as at the front, and experience has shown that the charge is evenly burnt throughout. From the bottom of the combustion-chamber the ignited gas is conducted by a flue passing immediately beneath the

kiln, thus heating it still further along its entire length, into a main flue that traverses the full length of the range of kilns, whence it can be gradually admitted by regulating-dampers into one or more of the adjoining kilns by branch flues that enter the front of the kilns, as shown in the drawings.

In describing the *modus operandi* of the new kilns, it is first of all necessary to explain that the entrance to the kiln is walled up after the coal has been kindled under each fire-hole. The admission of air is regulated by dampers at the fire-holes, and all the orifices on the front and the crown of the kiln are sealed up so as to exclude the admission of air. The practice is to admit the ignited gas by degrees into the newly-charged kiln or kilns adjoining that in operation, and to turn the full heat on only when the moisture has been expelled from the raw material to be burnt in the other kiln or kilns.

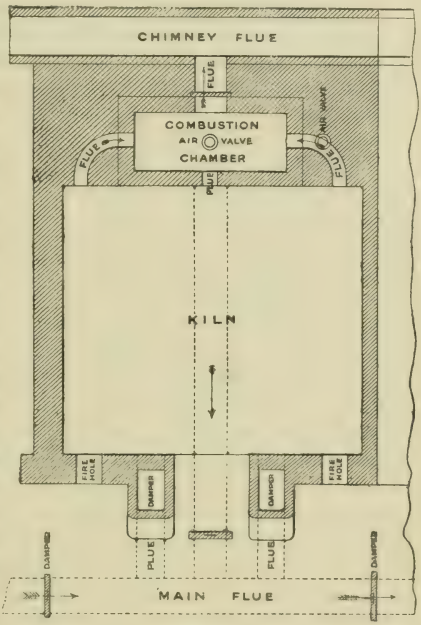

Fig. 4.

If none of the gaseous mixture is wanted at another kiln, the damper in the flue leading from the combustion-chamber into the chimney-flue is kept open and the damper for the underneath flue is closed. But when the ignited gas is required for another kiln, the damper in the connexion between the combustion-chamber and the chimney-flue is closed to an extent sufficient for sending round such a quantity as will dry the moist contents of that kiln; and the damper in the underneath flue is opened as well as the divisional damper in the main flue, and the dampers in the branch flues leading into the front of the kiln. After the moisture has,

in this way, been entirely driven off, the damper in the passage leading from the combustion-chamber to the chimney-flue is shut down altogether, and the whole of the heated vapour is passed through the contents of the second kiln and the combustion-chamber attached thereto into the chimney-flue; or, if it be desired to dry the contents of a third kiln, it is only necessary to close, or partly close, the damper in the flue connecting the combustion-chamber of the second kiln with the chimney-flue, and open the damper in the underneath flue, when the current will pass by the latter under the second kiln into the main flue, and thence by the branch flues into the front of the third kiln in the same manner as before described.

It has been found by experience that 6 tons of coal will, by the improved process, burn the contents of one kiln completely, and dry and heat to redness the contents of another; and that it is necessary to use 6 tons more of coal in the second kiln, in order to burn the charge in that kiln thoroughly. However, by the time that the charge of the coal in the second kiln is wanted the first kiln is done with; and the products of the combustion of the coal in the second kiln can be utilized exactly in the same manner as has been before described. And so the process goes on with the remainder of the kilns constituting the range.

Under the old system, each kiln at Moorhouse Guards colliery and brick-works held 8,000 best firebricks, which occupied 60 hours in burning, and cost £1 for labour during that operation. The consumption of coal amounted to 16 tons, costing £4. The total cost of burning the kiln was therefore £5, or 12s. 6d. per thousand.

Each of the patent kilns holds 10,000 best firebricks, occupies only 30 hours in burning, and costs only 10s. for labour. The coal consumed amounts to 6 tons, of the value of £1 10s. The total cost of burning firebricks by the improved system is therefore only £2 a kiln, or 4s. a thousand. The saving effected by the new kilns in the cost of burning is therefore about 8s. 6d. a thousand.

One of the new kilns can be used forty times a year, producing an output of 400,000 best firebricks, and effecting a saving of £170 during that period. It can be built for the sum of £100, exclusive of the royalty payable on the patent—little more than one of the old pattern kilns would cost. The improvements can be applied to existing kilns of the old type at a merely nominal cost.

The improved process of burning has been applied with equal success to the manufacture of common bricks by the Seaton Firebrick Company, and at a much reduced cost. By the old method, the burning of common

bricks cost 5s. 6d., whereas they can be produced with the improved kiln at a cost of, at most, 1s. 6d. a thousand.

Ten of these improved kilns have been in use at Moorhouse Guards for the last three years, and in addition to turning out the best class of firebricks, they have produced large quantities of fireclay-blocks for the lining of blast-furnaces, cupolas, tuyeres, stoves, etc., where intense heat has to be withstood, at various iron and steel-works in the district.

The following is a copy of an analysis made recently by Mr. W. Bedford, then of the Whitehaven Hæmatite Iron & Steel Co., Ltd., Cleator Moor, of a brick burnt in one of the improved kilns at Moorhouse Guards, showing clearly the refractory power of the firebrick :—

Gas in ignition, bituminous matter, and moisture	0·210	per cent.
Silica	72·500	,,
Alumina	27·000	,,
Iron oxide	0·071	,,
Magnesia	Trace	,,
Potash and soda	0·127	,,
Total	100·008	

The Chairman said that the paper described a very useful and interesting improved kiln. He agreed with the author that in an ordinary brick-kiln the products of the combustion of the coal used in the process of burning were allowed, after circulating through the charge of bricks, to escape direct to the chimney ; but in many instances, the waste heat was utilized under the drying-floor. At the present time brick-kilns were being fired by the waste heat from coke-ovens.

Mr. W. O. Wood said that the old kiln, of course, was not by any means perfect, but by long experience the fuel required had been reduced to a low figure, and the amount of waste was less than that referred to by Mr. Moore. The bricks at the back end of the kilns, ordinarily used in the county of Durham, are always as well burnt as those at the front end of the kiln, if the bricks have been properly set. The consumption of fuel mentioned in Mr. Moore's paper appeared very excessive. Under the old system, he stated that 40 cwts. of coal were used per thousand bricks. The old-fashioned kilns containing 8 to 8½ thousand bricks only consume 21 cwts. per thousand in this district. Mr. Moore states that the improved kilns use 12 cwts. of coal per thousand bricks. By adopting hot-air furnaces at the Cornsay brick-works, the consumption of coal has been reduced to 12·8 cwts. per thousand bricks, or about the

same quantity as is required by the improved kiln. The system of hot-air furnaces is being applied to round kilns, and it is expected that the fuel will be reduced to about 10 cwts. per thousand bricks.

Mr. T. Douglas said that the consumption of coal would of course depend to some extent on the character of the coal used. He thought that the consumption of the present kilns was too large, and much more than should have been used ; 2 tons per thousand bricks appeared to him to be an excessive quantity, and very much in excess of what was being used even now in ordinary kilns. Even the smaller quantity which was being used in the improved kilns would, he thought, be found to be in excess of the quantity consumed in the ordinary kilns of the Durham district.

Mr. W. C. Blackett said that he agreed with the remarks of Mr. Douglas and Mr. Wood. The kilns as they were burnt in this part of the country were not consuming anything like the quantity of coal mentioned in the paper as being used in the old kilns before the improvements were introduced.

Mr. Moore explained that the coal used for the burning of the kilns was small and duff of the very poorest quality, of which a larger quantity was necessarily consumed, and certainly not of the value which was put down in the paper of 5s. per ton. He had really put the price higher than it should be. He would like to know exactly the quantities and qualities of coal used at kilns in this district, so as to compare with those used in Cumberland.

The Chairman moved a cordial vote of thanks to the writer of the paper.

Mr. W. C. Blackett seconded the resolution, which was agreed to.

The following paper by Mr. J. M. Main on "The Working of Hæmatite in the Whitehaven District" was then read :—

THE WORKING OF HÆMATITE IN THE WHITEHAVEN DISTRICT.

By J. M. MAIN.

The working of the ores in the Carboniferous Limestone area of the Whitehaven district has hitherto not received much attention. The only description of which the writer is aware is a paper by Mr. J. D. Kendall, published in *The Transactions* of the North of England Institute of Mining and Mechanical Engineers,* and the same author's necessarily brief outline in his *Iron Ores of Great Britain.*† It is proposed to give, first, a general description of the working of the different kinds of deposits, and then to describe particular instances where special or marked characteristics have been observed, adverting also to some of the more important mining requisites that are in general use in the district.

Three distinct forms of hæmatite occur, viz.:—Vein-like, bed-like, and irregular or patchy masses, the latter locally termed "pockets," "sops," and "guts," the gut-like deposits continuing longitudinally for considerable distances, and often running parallel to the faults which are found near them, or with which they may be associated.

Vein-like Ore.

Vein-like ore occurs along the line of faults, of which there are a number in the district, and these are of primary or secondary importance according to their throw. It may be noted that the majority of the faults run in a north-westerly and south-easterly direction, and have an average bearing of about 45 degs. west of the true meridian. There are, however, instances of important faults (termed east-and-west faults) running almost at right angles to the other series (termed in contradistinction, north-and-south faults).

Vein-like ore occurs between two walls, locally termed the foot or lying wall, and the hanging wall, and in sinking a pit to work this class of ore, it is a point of good mining, and one which should never be neglected where practicable, to fix the site of the shaft on the upthrow side of the fault, and, if possible, clear of the outcrop of the vein at the surface, the object being to prevent damage to the shaft from drag, which

* Vol. xxviii., page 109. † Page 54.

in the case of a vein-like deposit of any magnitude is almost certain to occur. If the hade of the fault be low, this will necessitate longer drifts in the lower levels, and consequently make the first cost of developing the mine greater than would have been the case had the pit been sunk in the hanging wall directly on to the deposit, but this increased expenditure is much more than counterbalanced by the advantages gained (in subsequent working) from having the shaft in firm and solid ground.

If there are any insuperable difficulties in the way of sinking the shaft on the upthrow side, owing to the position of the fault in the royalty, then it should be sunk at a sufficient distance from the fault on the downthrow side to escape as far as possible from the effects of surface-drag.

There are no deposits of this kind in the district that can properly be designated true veins, nor are they always entirely vein-like, as in many cases a combination of vein-like and bed-like ore is found. This remark, of course, only applies to the geological area under consideration.

The usual method of working vein-like ore may be briefly described. Having sunk the shaft as above indicated, levels are driven off at right angles to the fault at distances of from 120 to 180 feet apart vertically, the number of levels depending on the extension of the vein in that direction. After the ore has been intersected and its width proved, longitudinal workings are commenced right and left, rises are put up on the footwall as the various workings advance, the pillars between each rise being from 60 to 70 feet in length. Intermediate horizontal workings are then driven from the rises, middlings of from 15 to 30 feet being usually left between, and thus the system of splitting up the vein goes on. The rises form hoppers, shoots, or (as locally termed) "hurries" for conveying the ore from the intermediate workings to the different levels communicating with the shaft.

Until communication by means of the rises has been effected with the different levels, the ventilation of the workings is obtained in the usual way, viz., by bratticing of brick or canvas, or by wooden boxes.

In the case of a wide vein, say from 100 to 120 feet, two longitudinal workings may be driven right and left from the shaft-drift, care being taken in so doing to "blind" the opposite workings, not only to strengthen the drift, but as a safeguard in carrying on blasting operations. Unless the hanging and footwalls are of a strong character, it is advisable not to drive the workings close to them, but to leave a portion of ore against them for support. The size of the workings varies from 8 to 20 feet wide and from 8 to 12 feet high. These dimensions are, however,

altogether regulated by the nature of the ore: where that is very hard and free from joints or cleats, larger workings than those stated may be safely carried on, and in such cases little or no timbering may be necessary. This, however, is the exception, not the rule, as in most deposits the character of the ore is subject to frequent changes, and renders timbering necessary to a greater or less extent, even in the first series of workings.

It may here be advisable to describe the method ordinarily adopted in timbering the ore-workings and driftways in such a deposit, and this description will suffice for the workings in the other forms of deposits hereafter to be described.

Sets consisting of two legs or uprights and a headtree are put in from 3 to 4 feet apart, the size of the timber used depending on the width of the working, the character of the ore, and the condition of the roof. When there is likely to be a considerable side pressure, the tops of the legs and the ends of the headtrees are half-checked or (as locally termed) joggled, to prevent the legs from being pushed from the perpendicular position, while the foot or bottom of the legs (usually the thickest part of the timber) is sunk, or, as it is termed in miners' phraseology, "has a footing made" some inches into the sole of the working, and if the latter is of a soft nature, pieces of flat timber are in addition placed immediately under the foot of the legs to prevent, as far as possible, their being forced downwards by top weight.

The joggling process is more especially necessary, if the working has for one of its sides the foot or hanging wall, the former consisting frequently of shale or slate-rock, and therefore liable to be affected by the air and dampness of the mine. Should most danger be apprehended from top or roof pressure, the upper ends of the legs are slightly hollowed out with an axe to receive the headtree, and thus obtain as good a bearing surface as possible. In weak or loose ground, coverwood (boards of from 5 to 12 inches wide, and from 1 to 2 inches in thickness) and sometimes also poling (the thin or top ends of the round timber) is placed over the top of the headtrees, and when the latter is used it is sometimes crossed by coverwood.

In drifting through fallen or broken ground, great care is necessary in fixing the timber, and the most experienced men are employed to perform this work.

After the deposit has been opened up in the manner described, and the workings in the upper levels have been carried to the extreme limits of the royalty, the work of taking out the middlings farthest from the shaft is

commenced, the ore in these being stoped in benches either from the top downwards or from the bottom upwards, as may be considered advisable. Some artificial blocking of the space between the two walls of the vein is often necessary before the ore can be taken out for any great distance. When the space between the walls is not too wide, a number of strong stemples may be firmly secured between and at right angles to the walls, and covered with 3 inches planks. All the *débris* and stone which may be got in carrying on the workings are piled on the top, and form in time an artificial middling, which may be further strengthened by putting in a few stretcher-props here and there. When it is difficult to obtain *débris* for packing, timber is used more largely.

If a wide deposit has to be dealt with, then stumps or parts of the middlings are left for the support of the walls. In such cases it often happens that a collapse of the walls occurs sooner or later, and any ore which may be buried in the fall can only be recovered by drifting through the fallen ground. These are termed robbery workings.

It is not always, however, in these deposits that workings can be carried on with rigid regularity for any length of time, as nips and enlargements of the ore-body occur frequently; while in some cases it may cut out completely and continue so for a considerable distance, or again it may become very much mixed with stone and other impurities.

The system of working the ore therefore cannot possibly be uniform, but must be designed to suit the special nature of the varying conditions. Where horses or large blocks of stone occur, these are, as far as possible, left undisturbed, and serve as supports to the walls of the vein.

The flats which frequently extend from these vein-like deposits are worked in a similar manner to the bed-like deposits noticed hereafter.

One of the largest and most productive of these vein-like deposits is that found on the north-west and south-east fault running through the Windergill, Postlethwaites Eskett, and Salter Hall royalties. The bearing of the fault on which this ore lies is about 34 degs. west of the true meridian. The longitudinal extension of the deposit through these three properties is about 3,000 feet, while it has been proved and worked to a depth of about 270 feet. It presents the usual characteristics of such deposits, viz., nips, enlargements, and flats. The latter occur in the third and fourth limestones.

Fig 1 (Plate III.), is a plan of some of the first workings of a vein-like deposit, the irregular direction of some of the longitudinal workings being caused by the nips and enlargements of the vein, while a long stretch of barren ground is seen in the lower levels. Fig. 2 (Plate III.),

is a section along the line A B (Fig. 1), and shows the relative vertical position of the various levels and workings as well as some of the characteristics of the ore-deposit.

Bed-like Deposits.

There are seven distinct beds of limestone, known as the first limestone, second limestone, and so on, which, together with the sandstones and shales separating them, form the Carboniferous Limestone series of the district. In each of these beds of limestone, hæmatite is found to a greater or less extent. The bed-like deposits are so called because they follow the dip or trend of the limestone-beds in which they occur, and frequently occupy a position either in the roof or sole of such beds, but sometimes they extend from roof to sole. They most frequently occur in the first, second, third, and seventh limestones.

The usual method of working this class of deposit is by the pillar-and-stall system. The pit is sunk in a convenient position in the royalty, and as far as possible to the dip. When the ore-bed has been reached, and adequate provision has been made either by sump or lodge for contending with the water, a level is driven at right angles to the dip of the strata, while, at the same time, a heading is carried on to the rise. As the branch workings on the levels advance, stalls, bords, throughs or (as locally termed) thirls, are commenced—leaving pillars 24 to 45 feet in length. From the heading also other workings are branched off, with from 18 to 36 feet of solid ground between each. The pillars thus formed (when the thirls from the various level workings are holed) measure from 430 to 1,620 square feet. Smaller pillars will suffice in the case of very hard and strong ore.

The width and height of the workings depend very much on the hardness and thickness of the ore and the nature of the roof. In the case of very hard ore with a good strong roof, and where the thickness of the bed will permit, the workings may safely and with advantage be made from 15 to 20 feet square, but when the ore is tender they are usually driven from 9 to 12 feet square, while timbering in the latter case is necessary, more especially if a shale-bed (as very often happens) overlies the deposit. No definite dimensions however can be fixed for regulating the size of the workings in these deposits as can be done, for instance, in the working of the thicker coal-seams, as the varying conditions met with render it impracticable.

The engineers or managers of these mines require therefore to exercise their discrimination and bring practical experience to their aid in coming

to a decision on this point, although the writer thinks that in many instances errors of judgment have sometimes been committed (especially in the earlier working of these deposits) in making the first workings both too high and too wide, and thus not only incurring considerable risk to life, but likewise causing great loss of mineral to the proprietors of the mines.

A working in one of the first pits that the writer descended in this district, about twenty-four years ago, was an instance of this error. The deposit was bed-like, and this particular working occupied the full thickness of the limestone-bed, extending from sole to roof, and measuring on an average 40 feet high. The whole of this height was taken in one working, with the exception of a hard band of ore in the roof, from 3 to 4 feet thick. This ore-band was left to support a black shale-bed above it, about 3 feet in thickness. The working at its greatest width measured about 100 feet, while it had a longitudinal extension at that time of nearly 200 feet. As all the ore had to be taken from the face to the shaft throughout the full length of this immense cavity, while at the same time a brake-road was in constant operation in the very centre of it, and as no reliable means could be adopted for testing the soundness of the roof, a covered way had to be made along the sole of the working at considerable expense, and involving great loss of time. Frequent falls from the roof occurred afterwards, although, fortunately, no serious injury to the miners resulted. This ore could have been worked in a much safer manner, and to greater advantage, had the first workings been of smaller dimensions.

The main heading is frequently used as the trail-road for bringing the ore from the various workings to the shaft, and so long as the gradient is light, "skutches" or sprags are used in running the loaded bogies or tubs down to the level drift. It frequently happens, however, that the beds rise at so steep an angle as to necessitate the making of an incline, worked either by a wire rope or chain and pulley, or by a drum furnished with an efficient brake. As the gradients of the beds are variable, sometimes running nearly flat, and at other times at a steep angle, a series of inclines are frequently in use in working a deposit. The full bogies (one or two at a time) bring up the empty ones, and swinging-platforms are used where the different workings connect with the inclines.

After the level workings have reached the extreme limit of the ore, either by being cut off by a fault or stone trouble, or by the boundary-line, the work of taking out the pillars is begun. When the roof is of a strong character, the pillar-ore can be obtained at considerably less cost

than when driving the thirls or stalls, the chief care necessary being to protect the line of workings either by pillars built of the stone that may be got in working the ore, or by pillars of wood or strong props. When wood is employed for this purpose, old railway-sleepers and squared Norway timber are very often used. Very little ore is lost under such circumstances, probably not more than 2 per cent., and where the ore is thin, the loss does not reach 1 per cent. More care is necessary and greater expense is incurred when the roof consists of a softer or less sound limestone or shale-bed, as a much larger quantity of timber is required, and in spite of all possible care being exercised, the superincumbent weight may cause a collapse of the roof. In such cases some of the pillars may have to be approached through fallen ground. Then slice after slice is taken off until the ore is removed. In this way the working back of the pillars is carried on, until that supporting the main heading is reached, which in the meantime is left undisturbed. The heading-pillars are then worked back from the inside in a similar manner until the deposit is exhausted.

Should the ore extend farther to the dip the shaft is deepened, and drifts or "eyes" are driven out at lower levels. The mode of procedure in working out pillar-ore is to commence at the rise side of the pillar, taking about 6 or 8 feet of the ore as a working-face, and carrying it down to the dip side of the pillar. When this has been done, and the roof behind secured as indicated, another strip of ore is in like manner taken out. Sometimes stumps of ore are left at the two corners of the pillars as a means of strengthening the roof, until the building of the stone or wood pillars is completed. These stumps can then usually be taken out with safety. Timber is set round the pillar in some cases, to keep up the roof whilst the pillar is being removed.

Where the ore-bed has been of great thickness and two tiers of workings are rendered necessary, the pillars of the top tiers may sometimes have to be left as near as possible over the bottom pillars with substantial middlings between the workings and strong arches of ore in the roof of the higher workings. The upper pillars are then first worked out, down to the sole of the top tier of workings. If the roof and ore are strong and hard, the working of the ore takes place from the inside outwards, but if the reverse conditions are present, then the working proceeds from the outside inwards, while the roof will require timbering. In the latter case, before proceeding with the work it may be necessary to support the roof of the lower workings, or fill them with *débris* (as afterwards described) if this has not already been done. When the top pillars have been brought back so far, as much of the roof-ore should be taken as can be

got out with safety; round larch timber is then placed across the top of the middlings with the ends resting on the top of the bottom pillars, and these are overlaid with coverwood and *débris* above the coverwood to a depth of 3 or 4 feet. The middlings may then be worked out from the bottom upwards, and the working of the bottom pillars afterwards commenced.

Should a general collapse of the workings take place before all the ore has been extracted, drifts are driven through the fallen ground from the nearest available points, and the ore worked out, as has already been described in speaking of robbery workings in vein-like deposits.

In certain conditions of the roof and ore, it is often considered advisable before commencing to remove the pillars, to pack with *débris* the waste area around them, close up to the bottom of the middlings—access drifts to the bottom of the pillars, and rises to the middlings being left through the *débris*. In this way, the ore in the lower tier of workings may be extracted with comparative safety, even should there be a collapse of the roof in the upper tier.

In some mines, instead of taking all the *débris* obtained from the various workings and development-drifts in the mine and depositing it on the spoil-bank at the surface, a large portion is used for the above purpose.

The bed-like deposits are subject to the same irregularities as those that occur in the vein-like deposits, viz., nips, vertical enlargements, and horses or large blocks of stone intermixed with the ore. These disturbances, of course, increase the cost of working the ore and render the above method of working liable to considerable alterations. The stone blocks are left as pillars, and they frequently deflect the workings from their intended course.

A good example of a bed-like deposit is that in Postlethwaites Fletcher pit near Moor Row. The ore is of a hard nature, but very rich in metallic iron, and has the advantage of a strong limestone-roof. In consequence of this, there is a very small percentage of loss in working out the pillars. The uniform extension of the deposit over a large area is also very marked. This deposit occurs in the second limestone.

Fig. 3 (Plate III.) shows the first workings in a bed-like deposit, and the pillars of ore left, as well as the stone disturbances that were met with. The ore averages 10 feet in height, and therefore was taken at the first working over the whole area. Fig. 4 (Plate III.) is a section of the same along the line A B (Fig. 3).

Irregular Deposits.

The third form of ore-deposit is that of irregular and patchy masses in the limestone. These deposits also occur in the vicinity of faults. They may be, and sometimes are, connected with vein-like and bed-like deposits.

This kind of deposit cannot be worked in any very systematic manner. The method usually adopted is as follows: assuming that the pit has been sunk and a level driven out to the ore, care must be taken not to drive the workings too large until the nature of the deposit is thoroughly understood. About 9 feet square is an average-sized working, but this of course is altogether dependent on the character of the ore. The first workings are driven in the same way as in the bed-like deposits, viz., by a series of working-places and pillars, until the enclosing stone is reached on all sides, and the horizontal extension of the ore at that level is known. If ore has been left in the roof, it is followed upwards either at the junction of the ore with the stone, or by plumb-rises in the ore at the most suitable points, with the view of ascertaining the vertical extension in that direction; and if the height of the ore will permit, another tier of workings is driven horizontally, leaving a middling of sufficient thickness between the sole of the upper and the roof of the first working. If the full height of the pocket of ore has been reached by the higher tier of workings, any leads of ore into the surrounding stone are now followed up, and, if the royalty is a rich one, other pockets of ore may be opened out in this way.

It may be that the connecting ore-lead is very small, and not workable to profit; but in this kind of deposit better results are obtained by following these than by drifting through the solid stone, unless ore has been proved by boring to lie at a convenient level, and at a short distance from some part of the working. In such a case, should there be no direct lead of ore, a stone-drift is at once driven in the direction of the borehole: advantage being taken of the existence of any shale-beds running in this direction, even although it may be necessary to go a little out of the direct course in doing so, the difference in cost in driving through limestone and shale being of material consideration.

The stone surrounding these irregular deposits is often of a very hard and siliceous character and full of loughs, rendering the operation of driving very slow and expensive. It may be here stated that the cost of driving a limestone-drift varies greatly, and ranges from 13s. to 40s. per foot, while a shale-drift may be driven at a cost of from 7s. to 16s. per foot.

As the development of the mine goes on, the workings will consist of a number of ramifications through the limestone.

Sometimes the connexion between one large pocket of ore and another is by a gut of ore of considerable size. These guts are usually enclosed between two stone backs forming the sides, and by an irregular roof and sole.

If any ore is left in the bottom of the first workings, a downward or dip working is made, and in the event of its continuance or further

development, the shaft is deepened and another level driven out. In this way it may be found necessary to drive a series of levels, one below the other, from the same shaft. In the event of the ore, cut by the first level, exhibiting a marked extension upwards, and necessitating the use of a number of hoppers or hurries before it can be conveyed to the shaft, it is often found advisable to set off an upper level from the same shaft, or should the distance be too great, to sink a new shaft from the surface.

Careful timbering is also required in the working of this class of ore, more especially if the pockets are of large dimensions. In the working of some of the smaller pockets, where the enclosing stone is of a hard nature, no timber may be required. Small guts in this kind of ground are worked as far as possible, from the dip to the rise, and are subject to similar nips and enlargements as those accompanying other forms of deposits. The guts usually run parallel to the main faults nearest to them, and often continue for considerable distances.

The workings are first carried to their farthest extension, and any ore left in the roofs, soles, or sides, is stripped off from the inside outwards. The taking out of pillars and middlings left in the mine after the ore-bearing area has been worked over, is carried on in a similar manner to that already described in dealing with bed-like deposits.

The irregular masses of ore in the old and new No. 1 pits, and the No. 4 pit of the Montreal mines, may be mentioned as one of the largest deposits of this kind in the district. An immense quantity of hæmatite of good quality has been raised from these mines during the last thirty years, and although the three forms of deposit are found in the royalty, by far the largest proportion has been obtained from the irregular deposit. Other deposits, such as High House and Crossfield No. 2 pit, have also been of an extensive character.

Figs. 5, 6, 7, 8, and 9 (Plate IV.) are plans of an irregular deposit and show the first workings therein at different levels. Fig. 10 (Plate IV.) is a section of the same deposit through the line E F.

Surface Deposits.

A notice of the workings of the various kinds of hæmatite deposits would scarcely be complete without touching upon surface deposits, as these, although coming under the category of irregular deposits, are sometimes worked opencast—a system of working which will only require brief notice.

This form of deposit usually occurs along the outcrop of some of the principal faults, or in dish-like undulations, in close proximity to these

faults. Some of them lie immediately under the gravel or Boulder Clay, termed the surface.

The deposit is worked as follows:—After the extent and nature of the deposit has been ascertained, the surface is stripped off the ore for a distance of from 10 to 12 feet clear of the outer edge of the deposit all round, the sides of the cast being well battered or sloped back. The deposit is then worked as a quarry, one side being first sunk so that a series of bench-workings can be carried on. The ore is drawn to the surface by means of an engine-incline, or by a portable engine from a shallow shaft, with drift-connexion to the bottom of the deposit. If the ore is of great thickness, a series of drifts may be required.

The principal opencast mines in the district have been those of the Cleator Iron Ore Company; Nos. 1 and 8 opencasts of the Crossfield Iron Ore Company; and Mr. Stirling's open-workings in the Montreal and Todholes royalties. In the case of the Crossfield and Montreal opencasts much difficulty has been experienced in the working of the ore, owing to the close proximity of the river Keekle, the bed of which had to be boxed or troughed over. This stream in wet weather is liable to sudden and heavy floods from its extensive watershed, although in dry seasons it contains very little water. It may be of interest to mention that the inside bottom width of this troughing is 20 feet, top width 29½ feet, and the depth 9 feet. The total length of the troughing in the two royalties is 1,584 feet. The first troughing was put in by the Crossfield Company in 1878.

Mining Requisites.

It now remains to describe a few of the principal mining requisites used in working the mines.

Timber.—English, Scotch, and Irish larch, peeled and unpeeled, is used for headtrees, legs, and general propping; while round or square Norway and Swedish timber is also used, the round sometimes for legs and props (but seldom for headtrees) instead of the larch, in places where the crush or overhanging weight is not excessive. Square Norway timber is used for building wooden pillars or splitting up into coverwood, wedges, etc. Boards (termed coverwood) of either home or foreign timber from 5 to 12 inches wide, and from 1 to 2 inches thick, are used for covering the top of the larch sets, while the small ends of the larch-trees as well as small foreign timber (termed poling) are also used for this purpose in places where the ground is of a loose or broken character. Poling and coverwood are sometimes used together.

Rails.—The rails used underground for bogie roadways are either the bridge or angle-plate sections weighing from 5 to 6 pounds per foot.

Bogies.—Both steel and wood bogies are in use, mounted either with flanged wheels made of cast-steel and about 12 inches in diameter for the bridge-rails, or with edge-wheels for the angle-plate rails. Different methods are adopted for fixing the wheels and axles. In some cases, the axles are fixed and the wheels run loose. In others, one wheel is fixed on the axle and the other is loose; and again sometimes both wheels and axles run loose. The length and width of a bogie at its centre capable of holding 10 cwts. of ore is 2 feet 7 inches by 1 foot 10 inches, and the height 1 foot 7 inches. They are, however, made of various sizes to hold from 8 to 12 cwts. of ore.

Jumper Steel.—As the great bulk of the ore in all parts of the district has to be blasted, it is of importance that a good and reliable steel be used. Twenty years ago nothing but double-shear steel of the best quality would stand the crucial test of boring through some of the harder ores and keeping an edge. For some years past, however, a cast steel has been introduced, which is equally applicable to the requirements of the district, and can be supplied at less than half the previous cost. The steel bar used is $\frac{7}{8}$ inch in diameter, round or octagonal (the former section being now most largely used). The length of the jumper varies from 1 to 4 feet.

The rate of progress made in jumper-boring varies with the hardness of the ore, and many cases occur where it would be considered a good day's work to bore 3 feet. On an average, however, a good miner will bore from three to four holes, averaging 2 feet in depth per shift.*

Explosives.—A great stride was made in developing and working many of the harder ores of this district, when dynamite and other kindred explosives were introduced. The sinking of shafts, and the driving of wet or damp stone-drifts and ore-workings, were much more laborious and lengthy operations in the days when nitro-glycerine compounds were unknown than they are now; and, as a consequence of the use of dynamite, some mines and a number of workings in most mines which were abandoned owing to their being unworkable to profit with powder, were recommenced, and in many cases with good results.

The different kinds of nitro-glycerine preparations in use at the present time are :—(1) dynamite; (2) gelignite; (3) gelatine-dynamite; and (4) blasting-gelatine.

The second and third varieties are, however, most largely used, being

* Mr. J. D. Kendall's *Iron Ores of Great Britain.*

considered stronger than the ordinary dynamite. Lithofracteur, gun-cotton, tonite, and oarite have also been used in the district to a limited extent. Very little blasting powder is now used.

As previously stated, the great bulk of the ore requires to be blasted ; but there are instances known to the writer, notably at the Southam mines, in the neighbourhood of Bigrigg, where a large proportion of the ore can be got with the pick. This of course reduces the cost of working the ore very materially. Cases of this kind are, however, very rare.

The detonators or caps used to explode dynamite charges are partially filled with fulminate of mercury, the quantity varying with the particular compound which they are intended to explode, quadruple or quintuple detonators being used with gelatine-dynamite, and sextuple with blasting-gelatine. The gutta-percha fuze fits exactly into the cap, the end resting on the top of the fulminate. In the case of damp holes, the cap and the part of the fuze connected with it are well covered with grease and nipped tightly together ; the latter is usually done in all cases. Nippers are supplied for this purpose, but the miners sometimes compress the top of the cap with their teeth—a most dangerous operation.

Candles.—The candles used are the ordinary dip tallow candle, numbering from 14 to 16 in the pound. A piece of plastic clay is put round the bottom of the candle, and by this means it can readily be made to adhere to any portion of the working-face in any position ; or it can be stuck on the front of a bogie, thus giving a good light to the trailer behind.

All the miners are strongly prejudiced in favour of the use of candles, and it would be difficult to convince them that oil or tallow lamps stuck in the cap, collier-like, are better adapted for use in metalliferous mines.

The attempt made in the foregoing paper has only been to give a general idea of the usual methods adopted in working these ore-deposits. To have dealt with the subject *in extenso*, and made reference to all the varying conditions which are met with in the development and working of some of the mines, as well as to have embraced the question of contending with the water-feeders and the pumping appliances in use for this purpose, would have necessitated a treatise of much greater length, and one altogether outside the scope of this paper.

The following paper by Mr. H. Mellon on "The Mining of the Softer Ores of Furness" was then read :—

THE MINING OF THE SOFTER ORES OF FURNESS.

By H. MELLON.

The district of Low Furness is bounded by the sea on three sides, and rising gently from the sea-level, it forms a piece of fine undulating country from 100 to 300 feet above sea-level, backed in the north by the hills of the Lake District.

On reference to a geological map of the southern portion of Furness, it will be seen that on the north are the Silurian rocks, then follows an irregular belt of Carboniferous Limestone, about five miles wide, stretching right across the district from east to west, this is followed on the south by the Yoredale Shales, Magnesian Limestone, and New Red Sandstone.

The rock-formations, except at a few places, are obscured from view by a thick covering of sand, gravel, and Boulder Clay. The latter is locally known as pinnel. The hæmatite deposits occur at the junction of the Carboniferous and Silurian rocks, on the line of faults, in wide fissure-like receptacles, and in irregularly-shaped dish-like hollows or caverns in the limestone immediately under the drift-covering. It is in this latter form that most of the softer ores of the district are deposited. The importance of the hæmatite deposits may be inferred from the fact that the quantity of ore annually raised in the district is about 900,000 tons, fully three-fourths of which is of the softer variety.

The limestone is thick-bedded, and has only a few thin partings of shale. It attains a great thickness southwards: thus, at Stainton 950 feet has been bored through. With one or two exceptions, which are on the line of great faults, the principal deposits of ore that have been so far discovered are confined to the north-western portion of the district, nearest to the site of the great elevatory movement, which brought up the rocks of Haume.

The deposits are not confined to any particular geological horizon, as there are deposits in the upper, middle, and lower beds of the limestone series. The deposits vary much in size, the largest discovered being at Park. It is of very irregular form, and measures about 1,500 feet in length from east to west, by 750 feet wide, and is proved over 600 feet

in depth; from this single deposit some millions of tons have been raised; other deposits contain thousands of tons, while there are small ones containing only a few hundred tons.

The general character of the softer ores is a confused mass of rough, fragmentary pieces of hard hæmatite, embedded in a matrix of softer ore, with which are mixed, to a greater or less extent, quartz, calcite, and clay. On the sides and floors of the ore-receptacles, and embedded in the ore, are large masses of vari-coloured clay and sand, with occasional blocks of country rock.

Some of the first deposits worked were no doubt discovered by their outcrop, others were exposed by the ploughshare or in cutting drains. In many places rude implements and other traces of ancient mining have been discovered, proving that these deposits have been worked from very early times.*

In searching for the deposits, it is usual either to bore by hand, or to sink small shafts through the drift in order to find where the ore comes to the surface of the limestone. The covering on the limestone averages from 30 to 70 feet in thickness. It is very difficult ground to bore through, on account of the many large and hard boulders that are met with; moreover boring may, to a certain extent, be misleading if not properly conducted, as the surface of the limestone is full of fissures, many of which are filled with ore, some perhaps only a few inches wide. If these were bored into by anyone unacquainted with the nature of the ground very erroneous conclusions might be drawn. The average cost of boring through this superficial covering is from 25s. to 30s. per fathom.

When there is little or no water, as very often happens, and the depth to the rock is not more than 60 or 70 feet, small trial-shafts ($4\frac{1}{2}$ feet square inside of frames) may be put down by windlass.

These are more satisfactory than boreholes, as on reaching the rock, drifting, for a short distance, may be carried out in various directions and the strata properly explored. To successfully carry out these explorations it is necessary to have a knowledge of the direction of the main dislocations and jointings of the strata; and if the comparatively small area which some of the deposits occupy be considered, the necessity for such trials being made, so that no large area is left unexplored, will be recognized.

The simple method of sinking by windlass and bucket is found to be the cheapest and best for a depth of 60 or 100 feet. These trials are

* A full description of the geology, history, and nature of mining in Furness, is contained in the *Iron Ores of Great Britain*, by Mr. J. D. Kendall.

quickly made, and the plant and materials are inexpensively moved from place to place. The cost is from 10s. to 12s. per foot, labour and materials included.

On ore being proved by one of the shafts, working is commenced at once. If the ore be found by boring, a shaft is sunk similar to the trial-shaft, and a level driven out into the ore.

The exploring-levels are kept small (6 feet high by 5 feet wide) and well timbered. The levels are put out in any direction that the irregularities of the roof and other interruptions will permit, a wheelbarrow and running-planks being used to convey the material to the shaft-foot, where it is filled into the buckets and wound to the surface. Winding by hand-power may be superseded by horse or steam-power. Horse-gins are still in existence in the district: they serve the purpose well for winding by bucket at these temporary shafts, which become twisted and crushed in all directions on the removal of the ore around them.

On the introduction of the horse-gin or other winding power, the drifts while in ore are opened up to the ordinary size of 9 feet high by 8 feet wide.

The diagrams (Figs. 1 and 2, Plate V.) show a plan and section of a typical soft-ore deposit in the limestone. The first levels (Fig. 2) from the gin-pit are shown interrupted by the irregularities of the roof. The pit is sunk deeper, and in the next levels the area of the deposit may be sufficiently proved to decide that a more permanent shaft must be put down, with suitable machinery. The site selected, taking into consideration the surface conveniences, is outside the area of the deposit, and far enough back from the edge, so as to be outside the area of the ground that may be drawn when the surface subsides.

The shaft is usually of rectangular form: 14 feet by $4\frac{1}{2}$ feet, inside of frames, is an ordinary size. This is divided into four compartments, two cage-ways, a ladder-way, and space for pumps. The frames and dividings are set either "skin to skin" or 20 inches apart, and backed by $1\frac{1}{2}$ inches boards. The first sinking may be for 120 feet, at which a level is driven out to the ore, and communication made with the gin-pit for ventilation. From this level "rises" are put up at convenient points to the level of the gin-pit workings. When the rises are to form a hopper (to deliver the ore by) and ladder-way, the usual size is 6 feet by $4\frac{1}{2}$ feet inside of the frames; but when it is required to send out by these rises, as is often the case, particularly from the first drifts or opening-levels, any sand, clay, or other matter separate from the ore, a larger-sized rise is required. The higher portions of the ore are worked out first.

The drifts will vary in height according to the height of the ore, and if the covering is a strong Boulder Clay, only very light timbering is required to support the roof; but if a sand or gravel roof, strong and careful timbering is needed. After the uneven portions are worked out the drifts of the usual size (9 feet by 8 feet) are made.

The first levels of a new height are driven out in various directions from the rises to the boundaries of the ore, leaving pillars of irregular size and shape; these are afterwards worked or robbed out, commencing at the outside, leaving behind the embedded masses of clay, sand, and stone where possible. When the ore at that height is exhausted the levels of another height or layer is commenced: thus a slice 9 feet in thickness over the area is taken out each time, the sole of the last height being the roof of the following. The plan (Fig. 1, Plate V.) shows this irregular form of pillar-and-stall working.

The great pressure of the superincumbent pinnel, etc., crushes down the timber as each height or tier is worked out, the broken timber and *débris* forming the roof of the next tier of workings.

The engine-shaft may be sunk in the first intance 200 or 250 feet, or it may be sunk an additional 60 feet, the usual depth between the levels driven out from the shaft at a time as required. Rises are put up in the ore each time to the levels above. After a few heights of ore have been worked out indications of the subsidence will appear on the surface, the removal of the ore round the gin-pit will cause it to collapse, and it may be necessary to sink another shaft, outside of the area of the deposit, for the purpose of ventilation.

From the time that the subsidence shows at the surface, the full weight of the surface-covering is carried on the timber of the workings. The timber largely used for prop-wood is larch, cut to lengths of props 7 feet, and headpieces 8 feet long: the diameter is from 5 to 10 inches, the heaviest and best timber being selected for the main roads. Two props and a headpiece form a set: these are fixed 21 inches apart and covered on the top with redwood boards, called "spiles," in lengths of 4½ feet by 4 or 5 inches wide by 1 inch thick (Figs. 3 and 4, Plate VI.).

When the forebreast of the drift has advanced 4 or 5 feet beyond the last set of wood, two sets are fixed, the boards are then driven in, one at a time from behind, by placing the end on the top side of the head of the first set fixed: one man holds down the front end of the spile, while the other drives it up from behind until it is even on the underside of the previous timbering. In the case of a loose friable top, the wood is kept

close up to the forebreast, and spiles are driven over each set, boards or slabs being placed at the back of the props to prevent the sides falling.

Some of the ore is very friable and quickly falls on exposure to the air and damp. In the first drifts, and where there is no roof pressure, boards are simply laid on the heads in the ordinary way.

On driving through masses of very fine wet sand or soft clay, special timbering is required to meet the pressure in every direction, rough hay and brushwood being used for packing to prevent the sand from running.

Main levels under great pressure in wet ground soon require extra timbering. On the first signs of any movement, additional props and heads lining sets are put in between those already fixed: the drift is then what is called close-wooded. After that additional props may be fixed under each head, resting on sole-pieces; the drift is then close-wooded and double propped (Fig. 5, Plate VI.). Occasionally the sole of the drift has to be boarded and sole-trees put in to prevent creep.

The ore is mainly got with the pick, occasional shots are put in to assist the getting by simply driving in a bar about 2 feet; the bar is provided with an eye by which to withdraw it, and the shot is usually put in near the top of the forebreast, the ore being first undercut in the sole.

The ore-pillars are worked out by taking off a drift-width at a time from the side.

On driving the first levels of each height, any sand, clay, or stone met with is sent out of the pit to the spoil-bank; after the opening-levels have been driven, any clay or sand, etc., is thrown back into the goaf. In the case of fine sand, the floor is first covered over with slabs and boards to prevent it from giving trouble in the next lower tier of workings. In this way the ore is worked out, commencing at the top of the deposit and taking horizontally slice after slice, 9 feet in thickness, until the deposit is exhausted.

Skilled miners are not required to simply use the pick and shovel, but it is requisite that they should understand how to place and fix the timber to keep the workings safe.

The prop and cover-wood being cut to standard sizes, the drifts should also be kept of uniform size. At some of the mines the prop-wood is prepared by special men, that is, it is hollowed out, or as it is termed collared, to receive the head-piece or collar, giving it a bearing the full width of the prop. When men prepare this wood for themselves they very often, to spare time, cut the end of the prop in a wedge shape, then

hollow it, giving the head a mere knife-edge to bear upon. (Fig. 6, Plate VI.).

Two men are employed in each drift, and they put their ore to the shaft-foot, or into the rise if not more than 150 feet distant. A small district is usually allotted to a company of men who may have three or four drifts in connexion with a rise. A trailer runs the ore from the rise to the shaft. Two men can put out from 5 to 6 tons net per set on an average, taking the driving of the first headings with the robbing out of the pillars. Contracts are often let, at a price per ton, to take out the whole of the ore over a fixed area for a single height of workings.

The average cost of the labour of getting and delivering the ore at the shaft is 1s. 9d. per ton net; and at this price men earn 5s. per set. The cost of timber is a heavy item in this class of mining: taking one deposit with another, it averages from 6d. to 8d. per ton of ore. The other charges are much the same as in other classes of iron-ore mining.

Strong wood-framed waggons, made to take into parts for convenience of getting up and down rises, are usually used in the rise workings; on the main drawing-levels ordinary sheet-iron waggons are used, containing from 8 to 12 cwts. each. The underground roads are made of the usual flat-bottomed rails or angle-plates laid to a gauge of 21 inches.

The ventilation of these mines is usually very good. By natural means, a good circulation is maintained when two shafts are connected.

In the case of only one shaft, it is usual to make one compartment of the shaft (connected with the higher levels) the upcast: this is assisted by a fire pan or steam jet. Small quantities of gas are occasionally met with on the re-opening of old workings: the gas is doubtless generated from the decomposition of the timber.

The drainage of these mines is generally a light matter, but there are exceptions where the ore deposits are of greater depth and on the lines of faults. The limestone being very cavernous, the rainfall quickly passes away. Many of the mines on the higher elevations are practically dry except during excessive rain, then the drainage-area, formed by the subsidences, collects the water in large quantities, which finds its way into the mine at a greater speed than the natural drainage can carry it off. To collect and divert all the water possible from the drainage-area of a mine is important; but it is a matter that is often neglected. The cost of mining this class of ore in the wet state is often more than double that of getting it dry: extra timber is required, there is more loss, and the ore is more difficult to separate from the impurities, consequently it is of inferior quality and of less value.

The quality of the softer ores differs considerably in the various deposits as well as in different parts of the same deposit. An average sample gives the following analysis :—

Silica	20·00
Alumina	1·50
Iron peroxide	71·50
Lime	·80
Magnesia	Traces
Sulphur	,,
Phosphoric acid	,,
Manganese dioxide	2·70
Loss by calcination	3·50
	100·00

The metallic iron at 212 degs. Fahr. is about 50 per cent.
The moisture averages from 8 to 12 per cent.
The specific gravity is 3·80.

During the past few years some of the inferior qualities of the softer ores have been treated by machinery, the most successful appliance being the Kennedy and Green ore-washer. This machine is in daily use at the Park and Roanhead mines. The ore treated contains from 35 to 38 per cent. of silica, and a large amount of clayey matter. In carrying out this process the ore is put into a revolving-sizer, by which it is disintegrated and washed : the rough portions fall upon a picking-table to be hand-picked ; while the finer portions being sized, are jigged or washed in the ordinary way. The ore falls upon a perforated tray in a box which is full of water. Connected with this is a piston, which causes the water to quickly rise and fall, the lighter matter is carried off by the flowing water, and the ore falls through the perforated tray into a box, the trays being covered with a layer of washed ore "bedding" of a larger gauge than the perforations. This machine can wash from 8 to 10 tons per hour. A more expeditious and less costly process of treatment for raising the quality of the poorer ores would be of great benefit to the district.

As regards the future, there are doubtless many deposits, both of the richer and poorer ores, still to be found in this large area which has been practically unexplored.

DISCUSSION ON MR. W. C. BLACKETT'S PAPER ON "THE COMBUSTION OF OXYGEN AND COAL-DUST IN MINES."*

Mr. H. Hall (H.M. Inspector of Mines) wrote that he had had an opportunity of inspecting and attending the inquest as to the Albion colliery disaster. This explosion was undoubtedly due to coal-dust, ignited by firing untamped dynamite shots, used to blow down roof timbers in a main intake airway (with 30,000 cubic feet of air passing per minute). This main intake was very dry and dusty, as were all the others in the colliery, with one exception. The explosive force and fire passed throughout the main intake airways, travelling over 4 miles in length. In each district the blast travelled inbye with the wind, increasing in violence as it passed forward, until it was able to distribute itself in the working-places, and there apparently dying out. The one wet district in the colliery alone escaped the blast; and the men in that district would have been saved had they not attempted to escape and met the after-damp—the horses stayed near the faces and took no harm.

Mr. W. N. Atkinson (H.M. Inspector of Mines) wrote that Mr. Blackett's paper was a thoughtful and valuable contribution to the much debated subject of explosions in coal-mines. There was, however, one point, referred to in different parts of the paper, to which he could not subscribe; that being the reason assigned for an explosion failing to traverse certain of the roads in a mine. The following extract from the paper referred to this point:—"There is no turning to the right or left, and no going through doors or stoppings into the returns; but as the explosion passes, down go these obstacles, beyond which, however, the road is not prepared, and therefore the explosion does not extend therein."† The subject is also referred to in connexion with certain roads not traversed by the explosions at Seaham and Usworth collieries. No doubt the "pioneering phenomena" spoken of by Mr. Blackett are essential conditions in the propagation of an explosion by coal-dust, but doors or ordinary stoppings would not arrest that process; they are blown out before the flame of the explosion reaches or passes them, and are frequently demolished at places never reached by the flame. Mr. Blackett recognizes that there may be other factors—in the quantity and quality of the dust—on the roads not traversed by the explosion; and he believed these to be true and sufficient reasons for the facts observed. He (Mr. Atkinson) had never observed an instance where a door or unstowed stopping had appeared to arrest the progress of an explosion when there was a supply of coal-dust on the

* *Trans. Fed. Inst.*, vol. vii., page 54.

† *Ibid.*, vol vii., page 56.

road on both sides of the door or stopping. That the progress of an explosion was frequently arrested near stoppings, and sometimes near doors, was due to the fact that the quality of the dust was frequently different on the opposite sides of the stoppings and doors, and not to any effect which an unstowed stopping or door had in preventing the "pioneering phenomena" described in the paper.

Mr. T. Forster Brown wrote that he held the opinion, dating from 1882, that with a blown-out shot in a main intake airway in a colliery where the dust was dry and fine (and, of course, pure coal-dust), it was not necessary that fire-damp should be present for an explosion to occur. His conversion to this opinion was due to the second explosion at Risca colliery in 1882, where an explosion occurred in the main intake airway, about 450 feet from the downcast shaft, where 80,000 cubic feet of air per minute was passing, and no possibility of fire-damp being present. The explosion travelled all through the colliery, damaged the ventilating fan at the surface, killed four shot-firers and all the horses in the mine. Since that date he had insisted upon dust being watered in all the steam-coal collieries with which he was associated.

Mr. Thomas Douglas said the members were all fully alive to the great importance of this question, and the fact that a Royal Commission had recently reported and made a valuable report in reference to it would excite interest in the matter for some time to come. Some of the members might be a little indisposed to agree that the greater proportion of explosions were due to coal-dust, but they would all be of one mind that coal-dust was a very important factor.

Mr. W. C. Blackett, referring to the remarks of Mr. Atkinson, admitted that the "pioneering phenomena" could only conduct the explosion along such galleries as contained a quantity and a quality of dust sufficient to develop combustion: and the main difference between himself and Mr. Atkinson was that the latter gave prominence to the quantity and quality of the dust, he (Mr. Blackett), while fully recognising this statement, gave additional reasons why certain roads were selected by the blast, and more particularly instanced the travelling-road at Seaham colliery. He (Mr. Blackett) believed that doors and stoppings had considerable effects in the guidance of a dust-explosion.

THE BRUNSVIGA CALCULATING-MACHINE.*

The Brunsviga calculating-machine performs addition, subtraction, multiplication, and division mechanically. The ordinary machine will give products not exceeding thirteen figures, or dividends not exceeding

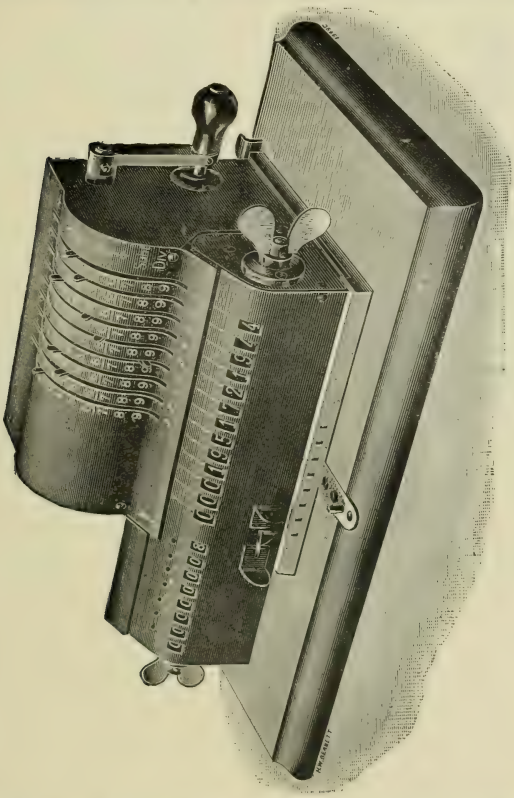

Fig. 1.

eight figures, in much less time than it is possible to obtain them by ordinary calculation. The large machine gives products up to eighteen figures. Its general appearance is shown in Fig. 1, whilst the details of its construction will be understood from Figs. 2, 3, and

* The illustrations are reproduced by consent of the proprietors of *Engineering*.

4. The operations of the machine are based on mechanical addition. Thus, to multiply by six, the quantity in question is added six times to itself.

The handle shown to the right of the machine (Fig. 1) turns a small spur-wheel which gears with a second, keyed on the main shaft of the machine, on which are also keyed a number of discs marked *a* in Figs. 2 and 4. Of these discs there are nine, corresponding to the nine slots shown in the upper part of the frame of the machine. Levers project through these slots, one to each of the nine discs. The handle being at rest in its normal perpendicular position (Fig. 1), if a lever is moved opposite any one of the numbers at the side of its slot, a corresponding number of teeth are caused to project from the previously smooth edge of the disc to which it is attached (Fig. 4). If now the handle be turned through a complete revolution, this disc revolves with it, and the projecting teeth move one of the number-wheels below into such a position that a figure corresponding to the number set by the lever appears at one of the openings below.

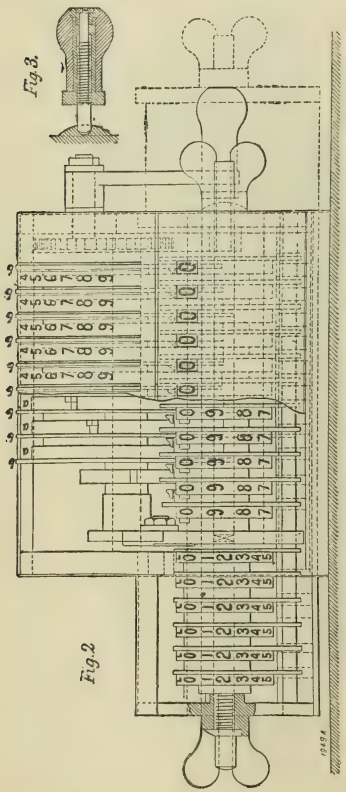

Fig. 2

To multiply by 2, the handle is turned round twice; by 3, three times, and so on; the number of revolutions of the handle being automatically registered at the small openings shown on the left side of the machine. To multiply by 27, the handle is turned round seven times, thus multiplying by 7, and then the sliding block carrying the

number-wheels is moved a space to the right, as indicated by the dotted lines in Fig. 2, and the handle turned round twice. The operation is, in fact, identical with the process employed in ordinary arithmetic. The figures 27 will now appear in the number-spaces to the left of the sliding block (Fig. 1), and the product at the large openings to the right.

In performing division, the operation is the inverse of this, and the handle is turned round in the opposite direction, thus subtracting the numbers set by the levers instead of adding them.

If by error, the handle has been turned in the wrong direction, the revolution must be completed, and the mistake rectified by turning the handle in the opposite direction.

When setting the levers, the handle must always be placed in its proper position. To ensure this, a stop is attached to the side of the machine, and the handle is fitted with a spring-latch (Fig. 3), which holds it securely in the proper position, whilst any desired numbers are being set by the levers.

The principal part of the mechanism is the series of discs carrying the movable teeth. Their construction is shown in Fig. 4, where *a* is the disc, and *b* is the lever which is set opposite the desired number on the frame. This lever is a projection upon a slotted plate, having a cam-groove *c* in it. In this groove lie pins, secured to the movable teeth, which run in slots, in the main disc. When the slotted disc is moved relatively to the main disc, a greater or smaller number of the pins pass into the outer portion of the slotted groove, and a corresponding number of teeth project from the main disc. A triangular stop fitting into the angular notches on the movable disc ensures that the disc stops in such a position with respect to the main disc that the movable teeth are either in or out, and that none project half-way.

Were it not for the necessity of "carrying" from one number wheel to another, no further device would be necessary; but when one number wheel is at 9, any further addition involves the carrying over of one unit to the next wheel. For this purpose each main disc carries two other teeth (one at either end of the row of nine principal teeth), which are used for the "carrying." In subtraction one of these teeth is used, and in addition the other. These teeth project permanently from the edge of the disc, but are held by a spring out of line with the main teeth, and so pass on one side of the teeth operating the number-wheels. When, however, a number-wheel is at 9, a cam connected with it comes into such a position that, on any further rotation of the wheel, a stop is caused to project, and gets in behind the carrying tooth of the next disc, pressing it

into line with the main teeth, so that it is brought into gear with the teeth driving the next number-wheel, which it accordingly turns through one division, and the "carrying" is effected.

Any number recorded on the number-wheels can be quickly cancelled by turning round the thumb-pieces shown at either end of the bar carrying the number-wheels. The thumb-piece on the right (Figs. 1 and 2) cancels any numbers appearing at the large openings, whilst that on the left performs the same operation for those appearing at the small openings. For this purpose the shaft on which the number-wheels are mounted is capable of a slight axial movement, but is normally kept from so moving by a spring. It has projecting from it a number of pins, one of which is shown at *d* (Fig. 4). These pins, when the shaft is in the working position, do not prevent the rotation of the number-wheels, which are cut away so as to afford a free space for these pins. When, however, the shaft is moved outwards a small distance, the pins come into contact with stops on the number-wheels, and carry these latter round with them, and when the shaft has finished its rotation each wheel shows zero at the openings.

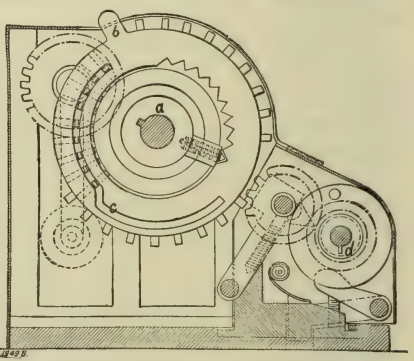

Fig. 4.

By means of a frame and gearing, three Brunsviga calculating-machines may be worked simultaneously by one operator, or one or two machines may be used as desired. Each machine can also be removed from the frame and used singly.

The machine is applicable to decimal calculations, no regard being made to the decimal point, which can be placed in position in the product, by the usual rules.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
ON SEPTEMBER 5TH, 1894.

MR. ARTHUR SOPWITH, RETIRING PRESIDENT, IN THE CHAIR.

The SECRETARY read the Annual Report of the Council as follows: -

THE FIFTH ANNUAL REPORT OF THE COUNCIL.

The Council are once more enabled to congratulate the members upon the success and increasing strength of The Federated Institution of Mining Engineers.

The Institution is intended to further the advancement of the sciences of mining, geology, metallurgy, engineering, and their allied industries, by the interchange of opinions, and by the reading of communications from members and others. Its prosperity could be materially increased by the members promoting its claims and advantages, and extending the membership.

The members receive the papers read at the meetings of the Federated Institutes, and participate at the two General Meetings held in each year in the various mining districts of the United Kingdom, and at the one held annually in London.

The influence of the Institution as representing mining engineers in their entirety would become materially effective, and the value of the *Transactions* be greatly enhanced if it included all the societies interested in mining, metallurgy, and their allied industries.

The large number of members resident in India and the Colonies might hold meetings, and the papers communicated and the accompanying discussions could be sent for incorporation in the *Transactions*.

The Institution now comprises six societies, viz.:—The Chesterfield and Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil, and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The number of members on the register since the formation of the Institution are:—

Year.	No. of Members.	No. of Non-Federated.
1889-90	1,189 ...	50
1890-91	1,187 ...	9
1891-92	1,414 ...	19
1892-93	1,533 ...	19
1893-94	2,068 ...	123

The status of the admission of members of the Federated Institutes has been considered, and the desirability of adopting a classification of their members, in accordance with Bye-law 8, is urgently suggested.

General Meetings have been held during the year in London, Scotland, and Yorkshire, and the members are to be congratulated upon the value of the papers communicated and the accompanying discussions. The thanks of the Institution have been conveyed to the gentlemen who kindly allowed their works and collieries to be visited by the members during these meetings.

Presidential addresses have been delivered during the year to the members of The Federated Institution of Mining Engineers by Mr. Arthur Sopwith; the Chesterfield and Midland Counties Institution of Engineers by Mr. William Spencer; the Midland Institute of Mining, Civil, and Mechanical Engineers by Mr. W. E. Garforth; the Mining Institute of Scotland by Mr. G. A. Mitchell; and the North of England Institute of Mining and Mechanical Engineers by Mr. A. L. Steavenson.

The following papers have been read upon geology:—

"The Formation of the Earth's Crust and its Destruction." By Mr. Henry Aitken.

"Geology, Mining, and Economic Uses of Fuller's Earth." By Mr. A. C. G. Cameron.

"The Ghorband Lead-mines, Afghanistan." By Mr. A. L. Collins.

"The Probable Range of the Coal-measures in Southern England." By Prof. W. Boyd Dawkins.

"The Coal-fields of Labuan, Borneo." By Mr. R. Fisher.

"The Gold-deposits of Siberia." By Mr. A. Foniakoff.

"Geology of the Southern Transvaal." By Mr. Walcot Gibson.

"The Mineral Development of Nova Scotia." By Mr. E. Gilpin, Jun.

"Note on the Antimony Deposit of El Altar, Sonora, Mexico." By Mr. Edward Halse.

"Note on the Occurrence of Mercury at Quindiú, Tolima, U.S. Colombia. By Mr. Edward Halse.

"The Structure of the Forest of Wyre Coal-field." By Mr. Daniel Jones.

"A Short Description of the Hæmatite Deposit Worked by the Salter, Eskett, and Winder Gill Mines, and the Method of Working it." By Mr. J. D. Kendall.

"Singareni Coal-field, Hyderabad, India." By Mr. J. P. Kirkup.

"Gold and other Mineral Resources of Western Australia." By Mr. R. H. Lapage.
"Geology of the West Yorkshire Coal-field." By Prof. A. Lupton.
"The Mid-Lothian Coal-basin." By Mr. R. Martin.
"The Coal-fields of Sonora, Mexico." By Mr. James Overend.
"Minerals and Mining in Tasmania." By Mr. A. P. Wilson.

Mining engineering has been dealt with in the following papers :—

"History and Description of the Greenside Silver-lead Mine, Patterdale." By Mr. W. H. Borlase.
"Notes on Work Done by the Stanley Heading-machines at Hamilton Palace Colliery." By Mr. J. S. Dixon.
"Limestone Mining in Scotland." By Mr. John Morison.
"Stoppings on Underground Roads." By Mr. E. B. Wain.
"The Jeffrey Electric Coal-cutting Machine." By Mr. R. S. Williamson.
"Notes on Coal-getting by Machinery." By Mr. T. H. Wordsworth.

The following papers have been contributed relative to mechanical engineering :—

"Safety-catches in Connexion with Mining Cages and Hoists." By Mr. Andrew Caseley.
"The Use of Expansion-gear as Applied to Colliery Engines." By Mr. M. Deacon.
"The Victoria Friction-clutch." By Mr. L. Dobinson.
"The Transmission of Power by Compressed Air." By Prof. Goodman.
'The Melling Steam Reversing-gear." By Mr. John Heath.
"Notes on Mr. R. H. Wynne's Paper on 'The Application of Mechanical Arrangements in Underground Operations.'" By Mr. T. Vaughan Hughes.
"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.
"The Bearing-surface of Pump-valves." Report of the Committee of the Mining Institute of Scotland.
"A New Pit Pump." By Mr. R. Thomson.
"The Application of Mechanical Arrangements in Underground Operations." By Mr. R. H. Wynne.

The following papers have been communicated on the subjects of mine ventilation, safety-lamps, etc. :—

"The Veitch-Wilson Improved Lamp-pricker." *Anon.*
"Safety-lamps with Standard Flames for Keen and Accurate Gas-testing." By Mr. J. Ashworth.
"The Hydrogen-oil Gas-testing Safety-lamp." By Prof. F. Clowes.
"The Proportion of Carbon Dioxide (Choke-damp) in Air which is Extinctive to Flame." By Prof. F. Clowes.
"The Sussmann Electric Lamp." By Mr. V. C. Doubleday.
"A Contribution to the History of Fire-damp." By Mr. H. G. Graves.
"The Friction of, or Resistance to, Air-currents in Mines." By Mr. Daniel Murgue.
"Result of an Experimental Research into Choke-damp Poisoning, with Special Reference to Oxygen as a Restorative." By Dr. W. Ernest Thomson.

The question of coal-dust has been discussed in the following papers :—

"A Contribution to our Knowledge of Coal-dust. Part II." By Dr. P. Phillips Bedson.

"A Contribution to our Knowledge of Coal-dust. Part III." By Dr. P. Phillips Bedson and Mr. W. McConnell, Jun.

"The Combustion of Oxygen and Coal-dust in Mines." By Mr. W. C. Blackett.

"Coal-dust in Mines and its Relation to Explosions." By Mr. C. Dunbar.

The use of explosives has been the subject of the following papers :—

"Notes on Blasting in Coal-mines." By Mr. H. Bigg-Wither.

"A New Method of Tamping and Ramming Boreholes." By Mr. H. Johnson.

"Mining Explosives: Their Definition as Authorized under the Explosives Act, 1875." By Mr. A. C. Kayll.

"Miss-fires." By Mr. J. D. Kendall.

The preparation of minerals has been considered in the following papers :—

"The Baum Coal-washing Machinery." By Mr. Fritz Baum.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

"Coal-washing at North Motherwell Colliery." By Mr. John Hogg.

"The Lührig System of Coal-washing." By Mr. G. Blake Walker.

Electrical subjects have been considered in the following :—

"The Best Means of Conveying Electric Energy in a Fiery Mine." By Mr. A. W. Bennett.

"The Sussmann Electric Lamp." By Mr. V. C. Doubleday.

"The Electric-power Plant at Dumbreck Colliery, Kilsyth." By Mr. J. T Forgie.

"The Jeffrey Electric Coal-cutting Machine." By Mr. R. S. Williamson.

The subject of "Rating of Mines" has been treated of in a valuable paper by Mr. E. J. Castle, Q.C., which resulted in a most interesting discussion.

The miscellaneous papers have been :—

"The Manchester Ship Canal." *Anon.*

"The Hilderstone Silver-mine, near Linlithgow." By Mr. Henry Aitken.

"An Open-scale Barometer." By Mr. C. O. Bartrum.

"Barometer, Thermometer, etc., Readings for the Year 1893." By Mr. M. Walton Brown.

"The Oil-shale Industry of France." By Mr. G. Chesneau.

"Spontaneous Combustion in Coal-mines." By Mr. W. S. Gresley.

"On the Report of the Royal Commission on Mining Royalties." By Mr. James Hamilton.

"Notes upon a Practical Method of Ascertaining the Value or Price to be paid for Zinc Mineral." By Mr. H. D. Hoskold.

"Photography in Mines." By Mr. H. W. Hughes.
"Description of the Whitehaven Collieries." By Mr. H. M. James.
"Leicester Sewage Pumping-station at Beaumont Leys." By Mr. E. G. Mawbey.
"Ancient Mining at the Coppice, Sedgley." By Mr. I. Meachem, Jun.
"The Salt Industry of Carrickfergus." By Mr. A. Miscampbell.
"Obituary of Thomas William Embleton." By Mr. T. W. H. Mitchell.
"Historical Sketch of the Whitehaven Collieries." By Mr. R. W. Moore.
"Description of the St. Helen's Colliery, Workington," By Mr. G. Scoular.
"Magnetic Declination and its Variations." By Prof. H. Stroud.

The foregoing lists, comprising 78 papers demonstrate the varied nature of the papers communicated to the members during the year. Many of the papers and the accompanying discussions are of great value.

Prizes have been awarded to the authors of the following papers, which are printed in volumes iv. and v. of the *Transactions:*—

"The Correlation of the Coal-fields of Northern France and Southern England." By Mr. Marcel Bertrand.
"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.
"The Geology and Coal-deposits of Natal." By Mr. R. A. S. Redmayne.

The "Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Foreign Societies and Foreign Publications" have been continued, and comprise many subjects of interest to members.

The bulk of the papers has necessitated the *Transactions* being printed in two volumes, an arrangement which will be received with satisfaction by the members.

BOOKS, Etc., ADDED TO THE LIBRARY.

Argall, P., Nickel, The Occurrence, Geological Distribution, and Genesis of its Ore Deposits, 1893.

Barrowman, J., Glossary of Scotch Mining Terms.

British Association for the Advancement of Science. Committee to Organize an Ethnographical Survey of the United Kingdom, January, 1894.

British Association for the Advancement of Science. Reports of Meetings at Leeds, 1890; at Cardiff, 1891; at Edinburgh, 1892; and at Nottingham, 1893.

Cadell, H. M., A Visit to the Coal, Oil, and Anthracite Districts of Pennsylvania, 1891; The Salt Deposits of Stassfurt, 1885; The International System of Water and Sewage Purification, 1891; The Occurrence of Plant Remains in Olivine Basalt in the Bo'ness Coal-field, 1891; Geology as a Branch of Technical Education, 1887; Notes on the Coal Question (with Diagram), 1890.

Campbell, W. G., South African Progress Based on Transvaal Gold, A Sketch of 1893 Results.

Chesterfield and Midland Counties Institution of Engineers, Transactions, vols. iv.-xvii.

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The Local Institutes in account with the Federated Institution of Mining Engineers, for the Year Ending July 31st, 1894.

Dr.

	No. of Members.		Balance due at the beginning of the year.	Amounts falling Due during the Year.			
	Federated.	Non-Federated.		Calls made during the year.	Excerpts.	Transactions, Reducing Plates, etc.	Total.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	324	...	...	304 6 0	7 7 6	3 0 0	314 13 6
Midland Institute of Mining, Civil, and Mechanical Engineers	220	...	...	205 18 0	11 19 8	4 0 0	221 17 8
Mining Institute of Scotland	371	113	...	371 17 0	21 1 8	3 0 0	395 18 8
North of England Institute of Mining and Mechanical Engineers	841	...	...	788 17 0	59 19 3	26 18 0	875 14 3
North Staffordshire Institute of Mining and Mechanical Engineers	201	10	70 13 6	196 3 0	13 2 7	1 10 0	281 9 1
South Staffordshire and East Worcestershire Institute of Mining Engineers...	98	...	24 7 9	93 2 0	2 4 10	5 0 0	124 14 7
	2,055	123	95 1 3	1,960 3 0	115 15 6	43 8 0	2,214 7 9

Cr.

	Amounts Paid during the Year.					Balance due at July 31st, 1894.
	Balance from previous year.	Calls.	Excerpts.	Transactions, Reducing Plates, etc.	Total.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	...	302 12 0	7 7 6	2 0 0	311 19 6	2 14 0
Midland Institute of Mining, Civil, and Mechanical Engineers	...	181 13 0	11 19 8	3 0 0	196 12 8	25 5 0
Mining Institute of Scotland	...	371 17 0	21 1 8	2 3 4	395 2 0	0 16 8
North of England Institute of Mining and Mechanical Engineers	...	782 1 0	59 19 3	5 10 0	847 10 3	28 4 0
North Staffordshire Institute of Mining and Mechanical Engineers	70 13 6	175 11 0	11 11 5	0 10 0	258 5 11	23 3 2
South Staffordshire and East Worcestershire Institute of Mining Engineers	24 7 9	71 5 0	...	...	95 12 9	29 1 10
	95 1 3	1,884 19 0	111 19 6	13 3 4	2,105 3 1	109 4 8

Dr. THE TREASURER IN ACCOUNT WITH THE FOR THE YEAR

	£ s. d.	£ s. d.	£ s. d.
July 31, 1893—			
To Balance at Bank	125 1 11		
„ „ in Treasurer's hands	20 7 1		
		145	9 0
To Subscriptions for year ending July 31, 1893—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers	28 18 0		
Midland Institute of Mining, Civil, and Mechanical Engineers	18 18 0		
North of England Institute of Mining and Mechanical Engineers	74 0 0		
North Staffordshire Institute of Mining and Mechanical Engineers	82 5 0		
South Staffordshire and East Worcestershire Institute of Mining Engineers	16 0 0		
		220	1 0
To Subscriptions for year ending July 31, 1894—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers £273 14 0			
Midland Institute of Mining, Civil, and Mechanical Engineers 162 15 0			
Mining Institute of Scotland 315 7 0			
North of England Institute of Mining and Mechanical Engineers 708 1 0			
North Staffordshire Institute of Mining and Mechanical Engineers 150 5 0			
South Staffordshire and East Worcestershire Institute of Mining Engineers 71 5 0			
	1,681 7 0		
Non-Federated—			
Mining Institute of Scotland £56 10 0			
North Staffordshire Institute of Mining and Mechanical Engineers 5 0 0			
	61 10 0		
		1,742	17 0
To Local Publications and Authors' Copies—			
Chesterfield and Midland Counties Institution of Engineers	7 7 6		
Midland Institute of Mining, Civil, and Mechanical Engineers	11 19 8		
Mining Institute of Scotland	21 1 8		
North of England Institute of Mining and Mechanical Engineers	59 19 3		
North Staffordshire Institute of Mining and Mechanical Engineers	11 11 5		
Carried forward	£111 19 6	2,108	7 0

FEDERATED INSTITUTION OF MINING ENGINEERS. Cr.
ENDING JULY 31, 1894.

July 31, 1894. By Printing—	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Transactions, Vol. II., printing	.....	2 0 0		
„ „ III., printing	.....	8 0 0		
„ „ IV., printing	.....	76 7 6		
„ „ V., printing	377 11 11			
„ „ V., plates	97 7 6			
		474 19 5		
„ „ VI., printing	381 3 3			
„ „ VI., plates	82 15 3			
		463 18 6		
„ „ VII., printing	243 7 7			
„ „ VII., plates	91 15 2			
		335 2 9		
			1,360 8 2	
Excerpts, Vol. II.	.....	3 17 0		
„ „ III.	.....	1 6 0		
„ „ IV.	.....	3 10 3		
„ „ V.	.....	55 15 5		
„ „ VI.	.....	71 19 5		
„ „ VII.	.....	44 6 11		
			180 15 0	
Galley Proofs for Revision ...	.....	.....	3 2 4	
Circulars	.....	.....	26 1 11	
Proofs of Papers for General Meetings		.....	16 17 0	
				1,587 4 5
„ Stationery, etc.	.....	.....	23 8 9	
„ Postages—Circulars	.....	4 0 3		
„ „ Correspondence ...	.....	19 10 1		
„ „ Transactions ...	.....	197 4 1		
			220 14 5	
„ Addressing Transactions ...	.....	.....	13 0 0	
„ Insurance of Transactions ...	.....	.....	1 0 0	
„ Binding, Library		6 14 3		
„ „ Sundries		0 14 6		
„ „ Transactions		63 17 6		
			71 6 3	
„ Reporting		.....	10 14 6	
„ Incidental Expenses		7 1 0		
„ Petty Cash		5 9 9		
			12 10 9	
„ Salaries, Wages, etc.		.....	389 9 0	
„ Indexing Transactions (2 years)		.....	17 13 4	
Carried forward			£759 17 0	1,587 4 5

Dr. THE TREASURER IN ACCOUNT WITH

	£	s.	d.	£	s.	d.
Brought forward	111	19	6	2,108	7	0
South Staffordshire and East Worcestershire Institute of Mining Engineers	3	0	3			
The Federated Institution of Mining Engineers	15	10	1			
				130	9	10
To Sales of Transactions, etc.—						
Chesterfield and Midland Counties Institution of Engineers	1	0	0			
Mining Institute of Scotland	0	3	4			
North Staffordshire Institute of Mining and Mechanical Engineers	1	1	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	5	7	6			
Members, etc.	102	5	0			
				109	16	10
To Reducing Plates—						
Chesterfield and Midland Counties Institution of Engineers	1	0	0			
Midland Institute of Mining, Civil, and Mechanical Engineers	3	0	0			
Mining Institute of Scotland	2	0	0			
North of England Institute of Mining and Mechanical Engineers	5	10	0			
North Staffordshire Institute of Mining and Mechanical Engineers	0	10	0			
				12	0	0
To Advertizements				454	4	2
				£2,814	17	10

THE FEDERATED INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

	£ s. d.	£ s. d.	£ s. d.
Brought forward	.....	759 17 0	1,587 4 5
By Travelling Expenses—Secretary	41 13 5		
„ „ „ Treasurer	11 10 0		
		53 3 5	
			813 0 5
„ Advertizements—Commission	104 9 6		
„ „ Printing	0 9 6		
„ „ Stamps	0 10 0		
		105 9 0	
„ Prizes, Vols. III. IV. and V.	... ...	30 0 0	
„ Translations of Papers	... ...	10 0 0	
„ Abstracts of Foreign Papers	... ...	76 17 6	
„ Barometer Readings	... ...	7 8 0	
„ Calendar	... ...	12 5 0	
			241 19 6
			2,642 4 4
„ Balance at Bank	... ...	89 6 0	
„ „ in Treasurer's hands	... ...	83 7 6	
			172 13 6
			£2,814 17 10

Liabilities.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Printing, etc.	300	0	0			
Postage of Transactions	20	0	0			
Abstracts of Foreign Papers	10	0	0			
Barometer Readings	5	0	0			
Prizes for Papers	15	0	0			
Advertizements Paid in Advance	31	14	2			
				381	14	2
Balance of Assets over Liabilities				707	15	9

I have examined the above Balance Sheet with the books and vouchers relating thereto, and certify that in my opinion it exhibits a correct view of the affairs of the Institution.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
August 23*rd*, 1894.

£1,089 9 11

ENGINEERS.—GENERAL STATEMENT, JULY 31, 1894.

Assets.

	£ s. d.	£ s. d.
Balance at Bank	89 6 0	
„ in Treasurer's hands	83 7 6	
		172 13 6
Subscriptions Unpaid, Year ending July 31, 1893—		
South Staffordshire and East Worcestershire Institute of Mining Engineers		9 16 0
Subscriptions Unpaid, Year ending July 31, 1894—		
Chesterfield and Midland Counties Institution of Engineers	1 14 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	24 5 0	
North of England Institute of Mining and Mechanical Engineers	6 16 0	
North Staffordshire Institute of Mining and Mechanical Engineers	20 12 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	12 1 0	
		65 8 0
Excerpts Unpaid—		
North Staffordshire Institute of Mining and Mechanical Engineers	1 11 2	
South Staffordshire and East Worcestershire Institute of Mining Engineers	2 4 10	
Members, etc....	1 1 4	
		4 17 4
For Reducing Plates—		
South Staffordshire Institute of Mining and Mechanical Engineers		2 0 0
Transactions Sold—		
Chesterfield and Midland Counties Institution of Engineers	1 0 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	1 0 0	
Mining Institute of Scotland	0 16 8	
North of England Institute of Mining and Mechanical Engineers	21 8 0	
North Staffordshire Institute of Mining and Mechanical Engineers	1 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	3 0 0	
		28 4 8
Advertizements to July 31st, 1894, outstanding		114 14 2
		397 13 8
Transactions in Stock—		
4 Volumes at 12s.	2 8 0	
12 „ 10s.	6 0 0	
6 „ 9s. 9d.	2 18 6	
1 „ 9s.	0 9 0	
9 „ 8s. 3d.	3 14 3	
750 „ 7s.	262 10 0	
14 „ 5s. 3d.	3 13 6	
1,267 „ 4s.	253 8 0	
3,135 Parts at 1s.	156 15 0	
		691 16 3
		£1,089 9 11

ELECTION OF OFFICERS.

The Secretary announced the following elections by the Council:—

President.

Mr. W. N. Atkinson.

Vice-Presidents.

Mr. J. B. Atkinson.	Mr. J. Daglish.	Mr. J. B. Simpson.
Mr. A. Barnes.	Mr. G. B. Forster.	Mr. W. Spencer.
Mr. W. F. Clark.	Mr. G. A. Mitchell.	Mr. A. L. Steavenson.
Mr. W. Cochrane.	Mr. J. Mitchell.	Mr. J. Strick.
Mr. R. H. Cole.	Mr. J. Nevin.	

Treasurer.

Mr. R. Guthrie.

Auditor.

Mr. J. G. Benson.

The Chairman said he had very much pleasure in introducing Mr. W. N. Atkinson, who was pretty well known to them all, and in asking him to preside. He could only say that during his term of office he was very much indebted to the assistance he had had from the members of the Council, who had made his path very comfortable. He hoped the same attention would be paid to his successor in the presidential chair.

Mr. W. N. Atkinson then took the chair, and said he highly appreciated the honour that had been conferred upon him by the Council in electing him President for the coming year. With the assistance and guidance of the Council and of their able Secretary, he trusted that The Federated Institution of Mining Engineers would continue to flourish as it had done in the past. It was a gratification to him that the first meeting over which he was called upon to preside was in a district where he met so many of his old friends. His first duty as President was to propose a vote of thanks to Mr. Sopwith, their late President, for the able manner in which he had discharged his duties during the past year. He was sure they would pass that vote with very great approval.

Mr. Thomas Douglas (Darlington), in seconding the proposal, said he was glad to know that Mr. Sopwith had been associated with the North of England Institute of Mining and Mechanical Engineers for the past thirty years. It was nearly fifty years since he (the speaker) entered the coal trade, and in 1852 he attended the first meeting of the North of England Institute of Mining and Mechanical Engineers. It was therefore with particular pleasure that, as President of that Institute, he could take the opportunity of giving a hearty welcome to all who had come to Newcastle on this occasion, and he hoped that their visit would be an interesting and instructive one.

The vote of thanks was carried with acclamation.

Mr. A. SOPWITH acknowledged the very cordial way in which the vote of thanks had been adopted. He admitted that it was with some degree of satisfaction he gave up the presidential chair, because after all there was a good deal of work connected with it, especially as they had such an energetic Secretary, who was always in communication on various subjects. He might say, however, that whatever work he had done in connexion with the welfare of The Federated Institution of Mining Engineers had been a work of pleasure. He could only say in conclusion that he appreciated very much their kindness and the cordial manner in which they had approved the vote of thanks.

The SECRETARY read the following paper by Prof. Hull on "The Discovery of a Concealed Ridge of Supposed Cambrian Rocks under the New Red Sandstone of Netherseal, near Ashby-de-la-Zouch, Leicestershire" :—

THE DISCOVERY OF A CONCEALED RIDGE OF SUPPOSED CAMBRIAN ROCKS UNDER THE NEW RED SANDSTONE OF NETHERSEAL, NEAR ASHBY-DE-LA-ZOUCH, LEICESTERSHIRE.*

By PROF. EDWARD HULL, F.R.S., F.G.S.

It is now generally recognized that the Carboniferous strata of Leicestershire and Warwickshire were deposited in proximity to old land-margins, composed of Cambro-Silurian rocks which jutted out in a north-westerly direction in successive headlands in the Carboniferous sea, and included intervening bays of submerged land. As the land gradually subsided during the Carboniferous period the land-margin gradually receded eastwards, and thus the Upper Carboniferous strata were deposited over wider areas than were the Lower. In this manner we can account for the absence of the Mountain Limestone and other Lower Carboniferous strata, such as the Millstone Grit, in Warwickshire and some parts of Leicestershire and South Staffordshire, while the Coal-measures are more or less fully represented. The old rocks of Charnwood Forest and of Hartshill are visible representatives of this ancient Carboniferous land which was not submerged throughout the Coal period. Similar observations apply to South Staffordshire.

One of the ridges referred to appears to have been struck in borings recently put down by the Netherseal Colliery Company, under the direction of Mr. G. J. Binns, for the purpose of testing the extension of the main coal-seam. The strata passed through were as follows:—

Trias—

New Red Sandstone (Bunter). Light reddish-brown pebbly sandstone ... ... 262 feet.

* A paper on these interesting borings is given in the *Report of the British Association* for 1893, page 745. On other occasions, the writer has dealt with the subject of the physical geology of the Carboniferous strata of England, particularly in *The Physical History of the British Isles*, pages 79-89, Plates VI. and VII.; "The Triassic and Permian Rocks of the Midland Counties," *Memoirs of the Geological Survey*, chap. xi., page 109. The presence of numerous rock-faults, owing to which the coal-seams are replaced by sandstone, especially in the Coleorton district of Leicestershire, is doubtless due to the proximity of this region to the old land-margin of the Carboniferous period. See "The Geology of the Leicestershire Coal-field," *Memoirs of the Geological Survey*, page 53.

Coal-measures—

Grey and black shales and sandstones, with coal and ironstone; plants abundant ... ... 514 feet.

Probably Lower Cambrian—

Reddish, purple, and grey grit, micaceous quartzite (vitreous quartzite in No. 2 borehole) ... 19 „

As the rocks at the bottom of the borehole appeared to be different from those of the Coal-formation, the writer was invited to go down and report upon their geological age. On examining the cores in company with Mr. Binns, the writer came to the conclusion that they belonged to a formation earlier than the Carboniferous; and very probably of Lower Cambrian age. In this view he had the concurrence of Prof. Lapworth, to whom he sent specimens of the cores on returning home.

We arrived at this conclusion (1) from the proximity of the rocks of this period at Hartshill and Charnwood Forest, (2) from the nature of the specimens brought up in the cores themselves, especially the quartzite, and (3) from the entire absence of plant-remains, which were so abundant in the overlying Coal-measures.

If the above view be correct it will be seen that the whole of the Lower Carboniferous series (including the Mountain Limestone, Yoredale beds and Millstone Grit, together with the lower beds of the Coal-measures themselves) are here absent. There is represented to us, in effect, a vast *hiatus* or gap in the geological sequence of the strata; for we pass at once from the Lower Cambrian to the Upper Carboniferous; the beds of the Ordovician, Upper Silurian, Devonian and Lower Carboniferous being altogether unrepresented.

Mr. W. Spencer (Leicester) had observed several cases, in Leicestershire, where the New Red Sandstone was reposing on granite or syenite, all the other formations being entirely absent. The discovery at Nethersеal colliery was of great interest, as it would form a guide to the occurrence of the older measures.

The President remarked that 19 feet was a short distance on which to base any positive conclusions as to existence of the older rocks.

Mr. A. Sopwith said it would be interesting to know with certainty the nature of the rocks lying below the Coal-measures, because the whole of the South Staffordshire Coal-measures (which were practically in the same district) rested directly upon Silurian rocks.

Mr. W. B. Scott (H.M. Inspector of Mines) said that he had recently examined the southern outcrop of the Worcestershire coal-field, and found quartzites similar to those referred by Prof. Hull to the Cambrian formation. If the base of the edge of the coal-field was formed of quartzites and other Cambrian rocks—as it was proved to be by the quarried rocks on the surface, without the necessity of a borehole—it was an easy matter to argue that the whole floor of the basin on which the coal-field had been deposited was formed of quartzite and Cambrian rocks. He thought that the borehole described should be considered as revealing the truth, and that correct conclusions had been drawn by Profs. Hull and Lapworth.

The President then proposed a vote of thanks to Prof. Hull for the paper.

Mr. T. Douglas seconded the resolution, which was cordially adopted.

The following paper by Mr. C. A. Stetefeldt on "The Stetefeldt Furnace" was taken as read:—

THE STETEFELDT FURNACE.*

By C. A. STETEFELDT, Oakland, Cal.

In the year 1867, the author erected a small experimental Gerstenhöfer furnace at the Manhattan mill, Austin, Nevada, for the chloridizing-roasting of silver-ores. The experiment was not a success. Although the ore was fairly well roasted, two difficulties presented themselves: (1) The roasted ore, owing to its sticky nature, accumulated on the lower rows of shelves above the fireplace, and had to be frequently removed. (2) A large percentage of unroasted dust escaped through the flue, leaving the furnace near the top. Further experiments were abandoned at the Manhattan mill, because the superintendent, a native of Ireland, considered the process a "chemical monstrosity."

In the following year, the first Stetefeldt furnace proper was put up at the Murphy mill, Ophir Cañon, Nevada. It consisted of a plain shaft, 4 feet square at the bottom, 3 feet square at the top, and 25 feet high, with one fireplace near the bottom and another fireplace—the so-called auxiliary fireplace—attached to the flue which connected the upper part of the shaft with the dust-chambers. The feeder, which closed the top of the shaft, consisted of a cast-iron plate with a number of narrow slits over which fluted rollers were revolving, similar to the feeder used for the Gerstenhœfer furnace. After starting the furnace, it soon became evident that roasting in the shaft was a complete failure. The dust, however, escaping through the flue, passing the flame of the auxiliary fireplace, and collecting in the dust-chambers, proved to be highly chloridized. This immediately led to the conclusion that a feeder of entirely different construction should be provided. Allowing the ore dropping down the shaft to collect on a piece of sheet-iron, it was observed that by far the larger portion was not scattered, but landed in the form of lumps or sheets; hence the heat could not sufficiently penetrate these dense ore-masses to effect their roasting. After a feeder had been constructed on the same principle as the one now in use, (the feeder shown in Figs. 1 and 2, is only more perfect in its mechanical details) the ore in the shaft roasted remarkably well, and the success of the Stetefeldt furnace became an accomplished fact. The furnace at the Murphy mill had been put up only as an experiment

* Principally compiled from various papers communicated by the author to the American Institute of Mining Engineers.

outside of the mill, and without provision to run in connexion with the latter. The ore was hoisted in buckets to the feeder, and an Indian squaw who faithfully turned a crank served as motive power for the latter. The construction of a new furnace had to be abandoned on account of the sudden failure of the Murphy mine to supply sufficient ore for running the mill.

In the year 1869, the author erected the first Stetefeldt furnace for actual mill-work at Reno, Nevada, at a mill belonging to the Nevada Land and Mining Company, an English corporation. The great success

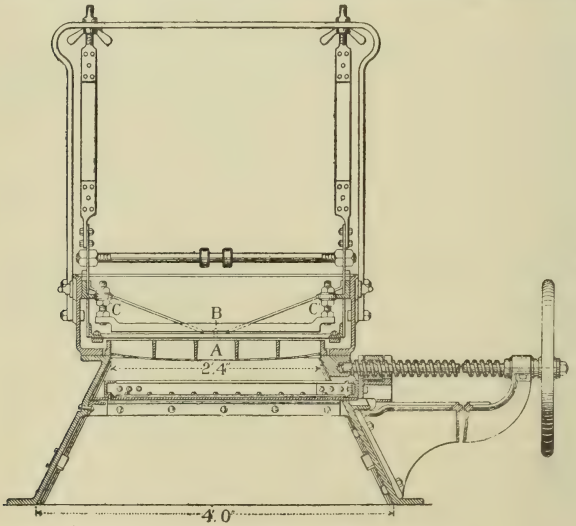

Fig. 1.—Longitudinal Section.

of the furnace at Reno induced the Manhattan company at Austin, Nevada, to acquire the exclusive right to use the Stetefeldt furnace in the Reese River district, by paying £5,000 and a royalty of 8s. per ton of ore, and the author built a furnace of improved construction at the Manhattan mill in 1870. Furnaces were now put up in quick succession in the principal mining-camps of Nevada, and subsequently in Utah, Montana, and Colorado.

1.—*The Stetefeldt Feeder.*—The Stetefeldt feeder, shown in Figs. 1 and 2, consists of a cast-iron grate A, covered by a punched steel-

sheet with holes of $\frac{1}{8}$ inch or less in diameter, through the openings of which the ore-pulp, mixed with salt, is fed by the oscillating motion of the wrought-iron rocker B. A coarse wire-screen, No. 4, is stretched over the frame of the rocker. The necessary friction is created by the stationary blades C. The distance between the punched-screen and the wire-screen, and between the latter and the lower edges of the blades, can be regulated, as also the number of strokes the rocker makes per minute, whereby it becomes possible to feed into the furnace, with the same machine, almost any desired quantity of ore. The coarser and warmer

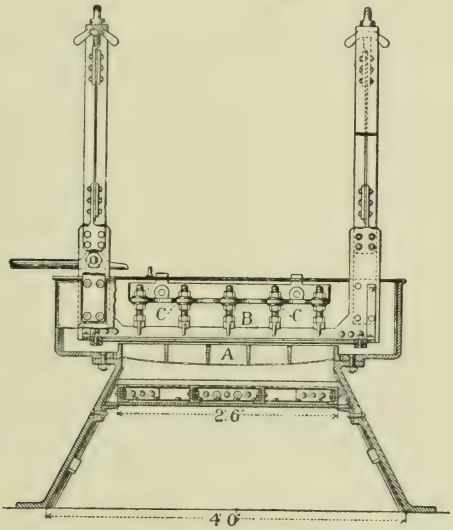

Fig. 2.—Transverse Section.

the pulp, the easier works the feeder. A damper, moved by a screw, is inserted below the grate A, whenever it becomes necessary to exchange worn-out screens. This is also done when the feeding of ore is stopped for any length of time.

The rocker of the Stetefeldt feeder, with coarse wire-screen, which was formerly supported by friction-rollers, is now suspended by adjustable, flexible steel-bands, as shown in Figs. 1 and 2. A change in the frame of the feeder was made many years ago. Originally it was in the form of a water-jacket. This caused a serious accident at Mineral Hill,

Nevada. The wise chief engineer of the mill had provided the influx as well as the discharge water-pipe of the jacket with cocks. Some thoughtless fellow had shut both cocks, and when the furnace was fired up, after a clean-up of the mill, the fireman noticed some steam issuing from the water-jacket. As he stepped near, an explosion took place, and, blinded by dust, the man staggered forward and dropped into the hot shaft. Although taken out alive, he died shortly afterwards. From that time the water-jacket was discarded, and it proved to have been superfluous.

It is hardly necessary to say that the feeder is continuously supplied with the mixture of ore and salt by a cup-elevator. The latter is fed from an ore-bin and from a salt-bin, both being provided with automatic feeders.

2.—*Construction of the Stetefeldt Furnace.*—The furnace at Reno had been provided with fireplaces for burning wood. In the Austin furnace, the author made a material change in constructing the two fireplaces for the shaft, and the auxiliary fireplace for the flue, in the shape of gas-generators for burning charcoal, or a mixture of charcoal and wood. In consequence of the excellent results obtained with this system at Austin, furnaces of the same construction were put up at Mineral Hill, Belmont, and Secret Cañon, all in Nevada. The author, however, soon discovered that such complicated apparatus was not safe in the hands of the average "muscular amalgamator," and returned to building furnaces with ordinary fireplaces for wood. At Belmont, an explosion destroyed the arches of the dust-chambers, the foreman of the mill having neglected to light the gas after starting the generators. At Secret Cañon, a quicksilver-bottle, filled with water, and fastened to a hemp-rope, was used as a counter-weight for the cover of one of the generators. In lifting the cover the rope broke, and the quicksilver-bottle dropped into the generator-shaft. The fireman did not consider that this might have serious consequences. After a while a terrific explosion shattered the walls of the generator, but fortunately did no other damage.

It is evident that in a furnace receiving fresh supplies of ore continuously, and performing the roasting in a few seconds, a uniform temperature must lead to better results, economically as well as from a metallurgical standpoint.

For this reason the author has recently returned with great success to the problem of firing the furnace by gas, made in a Taylor gas-producer from mineral coal. In 1890, he reconstructed the furnace at the Marsac mill, Park City, Utah, for gas-fires, and made the same change on the two furnaces of the Ontario mill, in 1893.

Figs. 3 to 10, in which the principal dimensions are specifically given, represent the latest design of the Stetefeldt furnace, as built at the Holden mill, Aspen, Colorado, in 1891.*

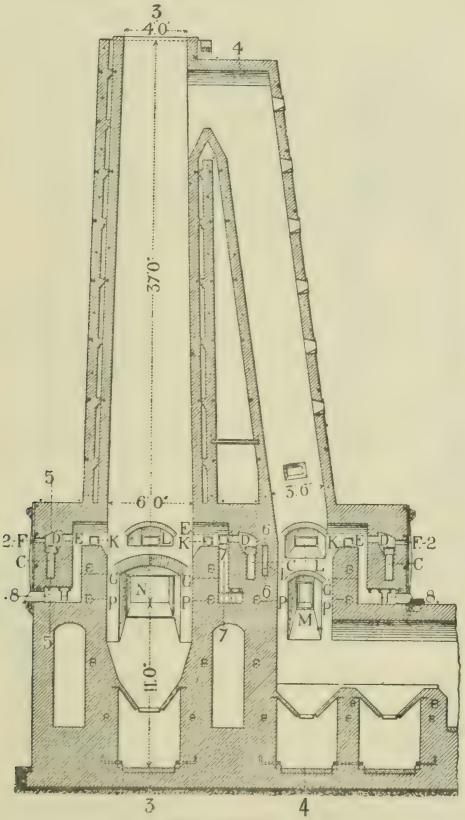

Fig. 3.—Section 1-1.

The spiral-weld steel-tube A, provided with expansion-joints B, supplies gas from a Taylor gas-producer to the cast-iron burners C, which have openings with covers in front for cleaning out soot and tar. The

* Drawings of the Stetefeldt furnace of older construction can be found in any of the recent text-books on metallurgy.

gas escapes from the burners through square holes on the top. These can be more or less closed by cast-iron slides (not shown in the drawings), the handles of which move through the covers of the frames D, thus regulating the supply of gas. The latter escapes into the combustion-chambers through the openings E. Should soot accumulate here it can be removed through

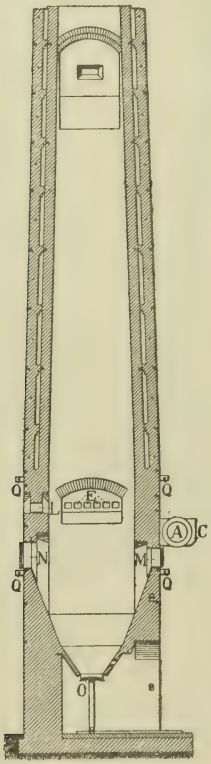

Fig. 4.—Section 3-3.

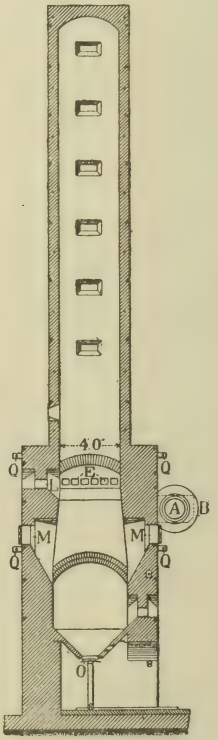

Fig. 5.—Section 4-4.

the pipes F, ordinarily closed by iron plugs. Air for combustion ascends through the channels G, and the air-supply is regulated by sheet-iron slides at the air-doors H. The air-channel I, in the wall between shaft and flue, is provided to prevent over-heating of the gas-burner. The fire-bridges can be cleaned through the openings K, and also through the doors L.

Air can be supplied below the fire-bridges through the doors M, and the big door N, on the shaft is used for cleaning the hopper. For discharging the roasted ore from the hoppers into cars beneath, the swinging dampers

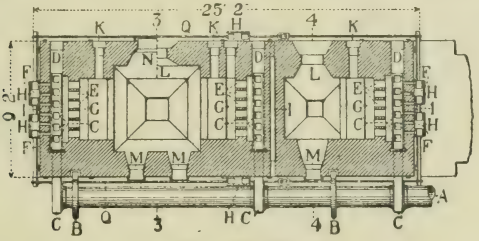

Fig. 6.—Section 2-2.

O, are pushed back by handles running in guides, which are not shown in the drawings. It will be noticed that many rails (30 pounds per yard) are inserted in the walls of the furnace. Anchor-holes P, running through hot walls, are made two courses of bricks high, 3 inches wide inside and wider at the faces of the walls, so that they are not closed by the perpendicular buck-straps. The long walls of the lower part of the furnace are anchored outside by the rods Q. All walls are braced by wrought-iron buck-straps between anchor-rods. Where ordinary bricks of good quality can be obtained, a lining of fire-brick is only necessary in the lower part of the shaft and flue, commencing about 4 feet above the fire-bridges in the shaft and at the fire-place in the flue. Other details of the furnace do not require description.

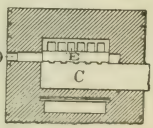

Fig. 7.—Section 5-5.

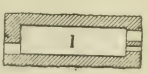

Fig. 8.—Section 6-6.

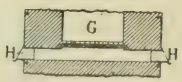

Fig. 9.—Section 7-7.

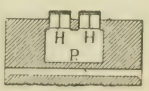

Fig 10.—Section 8-8.

The first furnaces built, roasting from 20 to 25 tons of ore per day, had no hopper-discharges, the charge being drawn with a hoe from the bottom of the shaft through a door. This proved to be inconvenient for a larger output, especially where the ore had to be banked on the cooling-floor in order to improve the chlorination of the silver. The height of the furnace has been increased from 30 to 48 feet, greater height being necessary for furnaces of large capacity roasting ores rich in sulphides, and partly on account of the arrangement of hopper-discharges.

3.—*Dust-chambers.*—The construction of dust-chambers, shown in Figs. 11-15, has not been changed recently. The chambers for large furnaces are generally built 4 feet wide, 10 feet deep, and 16 feet

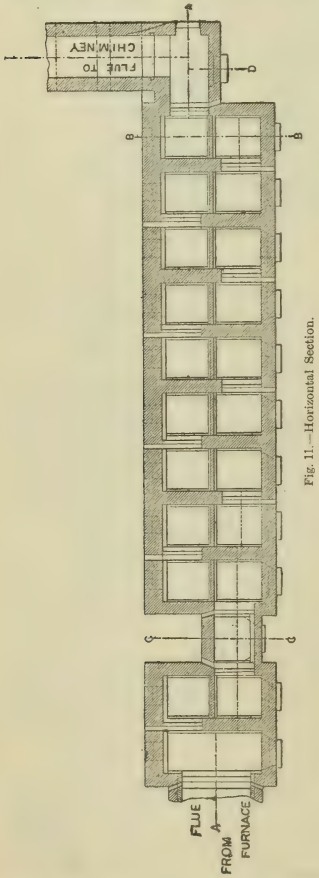

Fig. 11.—Horizontal Section.

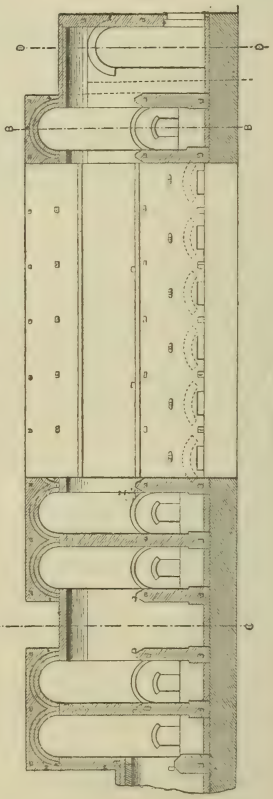

Fig. 12.—Section A-A.

high (inside dimensions). Each chamber is divided by an apron, so that the dust-laden gases have to travel up and down and sideways, thus constantly changing their direction, and impinging against the walls,

whereby a quick settling of the dust is effected. Dust from ore which has been well chloridized, by passing through the flame of the auxiliary fireplace, settles much better and quicker than raw or imperfectly roasted dust, because it is more or less sticky and adheres to a wall when carried against it by the draught. In an experiment at the Ontario mill, it was found that of the dust, escaping from the shaft of a Stetefeldt furnace, 82 per cent. settled in the flue below the auxiliary fireplace, 16·5 per cent. in the first six, and 1·5 per cent. in the last six dust-chambers. The first two dust-chambers next to the flue below the auxiliary fireplace get very hot, and for this reason they are separated from the other chambers whereby a better anchoring is secured. The floor of the dust-chambers is best made of cement-concrete, which lasts much better than a brick-floor. Cement-concrete is also used for the cooling-floor, which should be smooth for moving the ore-cars. The ground-plan of a large Stetefeldt

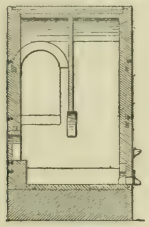

Fig. 13.
Section B-B.

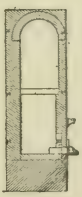

Fig. 14.
Section C-C.

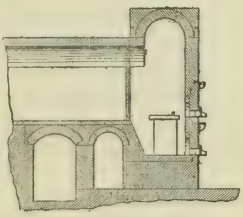

Fig. 15.—Section D-D.

furnace covers an area of 9 feet 2 inches by 25 feet 2 inches, and the dust-chambers, including their connexions with the furnace and the flue to the chimney, take up a space of 12 feet by 76 feet.

4.—*Chimney.*—A chimney for a large Stetefeldt furnace is built with a draught-section of 5 feet square, and the top of the chimney should be 100 feet above the top of the Stetefeldt furnace-shaft. Since silver-mills are generally located on the slope of a hill, it is advisable to run a flue, 4 feet wide and 6 feet high, from the last dust-chamber some distance up the hill, and build the chimney there. This flue, at the same time, serves as an additional dust-chamber and saves a considerable quantity of dust. It is always well to have a superabundance of draught, which can be easily regulated by a damper at the exit of the last dust-chamber.

5.—*Cost of Construction.*—It would be of little value to give the cost of erecting Stetefeldt furnaces in pounds and shillings. The table below contains a full statement of all materials necessary for building a Stete-

feldt furnace of the largest size, including dust-chambers, chimney, and pulp retaining-wall on the cooling-floor, from which estimates of cost can be made for a given locality. The construction of furnaces of smaller size is nearly as expensive, *i.e.*, they require about the same amount of castings, and the rest of the plant is not reduced in proportion to the capacity.

A. Stone and Bricks.—*Stone* for lower part of furnace and dust-chambers above foundation below level of cooling-floor, 3,000 cubic feet. *Common Bricks.*—From 250,000 to 300,000, according to length of flue between dust-chambers and chimney. *Fire-bricks.*—From 4,000 to 10,000, dependent on the quality of common bricks.

In calculating labour on brickwork, the following will serve as a basis :—One mason, with helper, will lay from 750 to 800 bricks per shift of 10 hours.

B. Castings and Ironwork :—

	Pounds.
Plain castings	12,250
Castings with finishing	3,600
Forged work	1,580
Sheet-iron work	760
Buck-straps	9,400
Plain wrought-iron bars	900
Bolts	4,300
Rails	9,600
Ore-cars (3)	1,250
Feeder	3,000
Punched screens (24)	300
No. 4 wire-screen (100 feet)	350
Total weight	47,290

This includes tools, and plates and anchor-bolts for the pulp retaining-wall on the cooling-floor. In addition to this, if the furnace is to be fired by gas, there will be the cost of a Taylor gas-producer of 6 feet in diameter, and of the necessary tubes for conducting the gas to the furnace.

6.—*Application of the Stetefeldt Furnace.*—The Stetefeldt furnace was especially invented and designed for the chloridizing-roasting of silver-ores, necessary for subsequent beneficiation by amalgamation or lixiviation; and in this field it has been, and is now, largely, successfully and exclusively used. Whether it can roast to advantage pyritic ores preparatory to smelting in reverberatory or blast-furnaces has never been proved or disproved, the smelters persistently refusing to try the experiment on account of the expense, because such a furnace must be built on a large scale. That silver-ores carrying a very large percentage of pyritic

mineral can be well chloridized in a Stetefeldt furnace has never been claimed, because this cannot be done directly in a reverberatory-furnace either. In the latter furnace, an oxidizing-roasting of ores high in sulphur always precedes the admixture of salt. Hence, if such ores are to be chloridized in a Stetefeldt furnace, they should be first partly desulphurized either by heap-roasting or by roasting in a Gerstenhöfer or Hasenclever furnace. The ore from the Sombrerete mine, Mexico, was only successfully chloridized in a Stetefeldt furnace, after it had been subjected to a somewhat crude and hasty heap-roasting.

There has been, however, a good deal of misunderstanding about this point. Some metallurgical writers have said that the Stetefeldt furnace could be used only for roasting oxidized or so-called "chloride ores," because they happened to see a furnace in operation on such material; others have limited its use to ores containing below 3 per cent. of sulphur, misled by an equally limited experience. As a rule, no sulphur determinations have been made in mills where the Stetefeldt furnace roasted ores of more or less base character; in two instances, however, this was done. The Ontario base ore from the 500 feet level contained 7·68 per cent. of sulphur before roasting, and the roasted ore from the shaft contained 0·18 per cent., and that from the flue 0·06 per cent. of sulphur, *i.e.*, in undecomposed sulphides. The mineralogical composition of the Ontario ore was as follows :—

15·00	per cent. of zinc-blende, containing	6·0	}	per cent. of
7·60	„ galena, „	5·8	}	the silver
4·55	„ fahlore, „	88·2	}	in the ore.
3·50	„ iron pyrites, „	Trace.		
69·35	„ gangue, composed of quartz and clay.			

In an average pulp sample, from 30,000 tons of ore at the Aspen mill, 8·1 per cent. of sulphur were found before, and 0·2 per cent. after chloridizing-roasting. A complete analysis of the ore gave the following result :—SiO_2, 21·7; $BaSO_4$, 20·9; CaO, 11·0; MgO, 4·2; Fe, 10·0; Zn, 2·9; Pb, 2·3; Cu, 0·16; S, 8·1 per cent.; silver, 24 ounces per ton.

7.—*Capacity of the Stetefeldt Furnace.*—The capacity of the Stetefeldt furnace, like that of any roasting-furnace, is principally a function of the percentage of sulphur in the ore; with good draught, however, it appears to be almost unlimited. The older Stetefeldt furnaces had very light work to do, the capacities of the stamp-batteries for crushing the ore rarely exceeding 30 tons per day. In recent times much larger quantities of ore have been roasted per day. At the Ontario mill, the regular output of one furnace is 40 tons of ore per day; experimentally, however, one

furnace has roasted at the rate of 126 tons per day, using a No. 6 screen on the battery. The Marsac furnace roasts 70 tons per day, and the furnace in the Aspen mill handles easily 90 tons per day, the ore carrying 8 per cent., and more, of sulphur.

8.—*Fine Crushing.*—Those who have had no experience with the Stetefeldt furnace are still under the impression that for chloridizing-roasting the ore must be pulverized exceedingly fine, finer than for any other furnace. This is absolutely erroneous. If silver-ores are to be roasted in a Stetefeldt furnace to prepare them for extraction by amalgamation or lixiviation, they do not require finer crushing than for roasting in Brückner, Howell, or reverberatory-furnaces.

In all cases alike the required fineness of crushing (the author refers here to crushing by stamps exclusively) depends on the character of the ore, *i.e.*, whether the silver-bearing minerals are finely impregnated in the gangue or not. In amalgamation the coarseness of crushing is limited by the capacity of the settlers to work off coarse sand; and this limit is a 26 mesh wire-screen. For lixiviation there is no limit of coarseness, and the most advantageous size of the screen is entirely dependent on the character of the ore. The Ontario ore is very interesting in this respect. Its principal silver-bearing mineral is fahlore (or its products by decomposition), and this never impregnates the quartz, but occurs in little bunches, and frequently on the cleavages of zinc-blende and galena. The latter minerals, if pure, are comparatively low in silver. How little coarse crushing affects the roasting of Ontario ore in the Stetefeldt furnace is shown by the following table:

Mesh of Screen on Battery.	Tons Crushed in 24 Hours.	Rate at which the Stetefeldt Furnace was Fed in 24 Hours.	Salt Used.	Silver Extracted by Russell Process.
	Per Stamp.	Tons.	Per Cent.	Per Cent.
20	$2\frac{3}{4}$	55	12.5	97·0
16	$3\frac{1}{2}$	70	12	97·1
10	$4\frac{1}{2}$	91	14	93·4
6	$6\frac{1}{3}$	126	8	91·9

The lower extraction in the last two experiments may have been due more to overtaxing the capacity of the furnace than to coarse crushing. In the last experiment the lower percentage of salt may have influenced the result. Ontario ore, however, is very exceptional in this respect, and there may not be many ores that could be roasted successfully for lixiviation after crushing through a No. 6 battery-screen.

9.—*The Chlorination of Base Ores on the Cooling-floor.*—It is well known that high chlorinations of silver-ores, containing a large percentage of pyritic minerals, can only be obtained after roasting in a Stetefeldt furnace by leaving the discharged ore for twenty-four hours, or longer, in heaps on the cooling-floor. The same remark applies to the Howell furnace. The incomplete desulphurization and chlorination of a base ore, immediately after discharging from a Stetefeldt furnace, shows itself by the pungent smell of sulphurous and sulphuric acids, and by the presence of a large percentage of magnetic oxide of iron (which can be extracted by a magnet), provided the ore was rich in iron pyrites. After sufficient exposure on the cooling-floor the magnetic oxide disappears either almost entirely or is at least greatly reduced in quantity. Thus, for instance, base ore roasted in the shaft of the Lexington furnace contained 17·5 per cent. of magnetic oxide immediately after discharging, and only 2·3 per cent. after having remained for twelve hours on the cooling-floor. The chlorination of the silver increased during this time from 47·7 to 90·8 per cent.

The question is pertinent: How is the chlorination of the silver effected in heap-roasting? In the first place, the roasted ore piled up on the cooling-floor is by no means inaccessible to the air; on the contrary, it is very porous. While the access of the air is slow, it is practically unlimited if sufficient time be allowed.

The lower oxides (and their salts) of copper, manganese, and iron, easily combine, and their higher oxides easily part with oxygen under certain conditions, thus acting as transferrers of oxygen to other compounds which do not combine with it directly. This is beautifully illustrated by the conversion of sulphurous into sulphuric acid in the Roessler converter. In heap-roasting a similar reaction takes place. Here, the oxygen of the air, at first, slowly attacks the sulphur in the undecomposed sulphides and forms sulphurous acid. The latter, remaining in contact with the higher oxides of copper, manganese, and iron, is converted into sulphuric acid, which decomposes the salt and sets chlorine free. That the lower oxides again combine with oxygen to higher ones is proved by the conversion of the magnetic oxide to ferric oxide inside of the heap after sufficient time has elapsed. As, in the Roessler converter, the reducing and oxidizing reactions, producing sulphuric acid, go on simultaneously; but they cease when all the undecomposed sulphides have disappeared, or the temperature has become too low. If the access of air were excluded none of these reactions could take place in heap-roasting. With the reactions effecting

the chlorination of the silver we need not concern ourselves here. The author has observed that, other conditions being the same, silver-ores containing a fair percentage of copper can always be more highly chloridized than those in which copper is absent, or occurs only in very slight quantity. This is due to the fact that copper is the most energetic transferrer of oxygen, of the three metals named, in the formation of sulphuric acid.

10.—*The Constitution of the Ore after Roasting in the Stetefeldt Furnace.*—Samples of roasted Ontario ore (the mineralogical composition of the raw ore has been given above) taken immediately after discharging from the shaft and flue, were subjected to a partial chemical analysis with the following results :—

Roasted ore from the shaft—	Per Cent.
Cupric and cuprous chloride	0·25
Zinc chloride	1·38
Aluminium chloride	1·51
Sodium chloride	3·68
Traces of other chlorides.	
Lead sulphate	3·26
Aluminium sulphate	0·56
Sodium sulphate	4·62
Traces of other sulphates.	
Remainder: Metallic oxides and gangue.	

Roasted ore from the flue—	Per Cent.
Aluminium chloride	1·07
Sodium chloride	3·08
Traces of other chlorides.	
Copper sulphate	0·74
Zinc sulphate	1·48
Aluminium sulphate	2·88
Lead sulphate	5·18
Sodium sulphate	10·01
Traces of other sulphates.	
Remainder: Metallic oxides and gangue.	

The separation of the soluble metallic chlorides and sulphates was effected by alcohol, in which the chlorides are soluble, and the sulphates are not. After treatment with alcohol, the soluble sulphates were extracted by water.

It appears from these analyses that copper and zinc are only present in the shaft as chlorides, and in the flue only as sulphates. The sulphates of lead and aluminium predominate in the flue, and aluminium chloride predominates in the shaft. Sodium sulphate also predominates in the

flue. Whether this holds good generally with ores roasted chloridizing in the Stetefeldt furnace the author does not know, such investigations not having been carried out elsewhere.

11.—*The Volatilization of Silver by Chloridizing-roasting in the Stetefeldt Furnace.*—The evaporation or volatilization of all substances is governed by the same general laws. The effective elements are: Time, temperature, surface exposed, character of the atmosphere in which evaporation or volatilization takes place, density or pressure of the latter, and its motion or exchange in relation to the substance evaporated or volatilized. Thus, for instance, more silver is volatilized in roasting a small ore-sample in a muffle than in actual reverberatory-furnace work, because more surface is exposed, and the particles have more contact with air in the former case.

If we enquire which of the elements favouring evaporation or volatilization is the most effective—other conditions remaining more or less the same—we must concede that it is time. Now, in the Stetefeldt furnace the roasting, so far as desulphurization is concerned, is instantaneous compared with the same process in any other furnace; hence the claim that the loss of silver by volatilization in the Stetefeldt furnace is a minimum. Unfortunately the actual and direct proof that this view is correct under all circumstances is lacking. The ordinary metallurgical statistics of silver-mills are perfectly worthless for such delicate investigations. In the first place, in mills reducing ores from mines belonging to the same company, the weight of the raw ore is only taken approximately and without making moisture-tests. In the second place, the so-called commercial assays for silver, on which all mill-statistics are based, is from 5 to 15 per cent. short of the actual value, whence originate the so-called "plus clean-ups" of silver.

To ascertain the loss of silver by experiments on a large scale in a direct way, namely, by weighing and sampling the ingoing raw ore and the outgoing roasted ore is attended with so much inconvenience and expense that the writer has never been able to find parties in charge of any mill employing Stetefeldt furnaces willing to undertake it. Hence, he had to get at the question by an indirect method. If a sulphide ore be subjected to an oxidizing-roasting the outgoing elements are generally of greater weight than the ingoing ones, and the result is a loss in weight. The same is the case in chloridizing-roasting, provided we compare the weight of the raw ore without salt with the weight of the roasted ore after leaching out the soluble salts. Under the circumstances it follows

that the assay-value of the roasted ore must be greater than that of the raw ore, in proportion to the loss in weight which the latter has suffered, provided no silver has been volatilized. If, however, the roasted ore should fail to come up to the required value no other inference can be drawn but this, that silver has been lost in roasting.

In 1880, the writer carried out at the Ontario mill, under circumstances that are not likely to occur again, a series of comparative experiments on the Stetefeldt and Howell furnaces. In one of these experiments the ore treated by both furnaces was exactly the same. It came from the same stamp-battery, and after being elevated to a hopper was distributed from the spout of a conveyor-trough, one-half going to the Stetefeldt and the other half to the Howell furnace. The latter had been provided with a system of dust-chambers as complete and well-constructed as that attached to the Stetefeldt furnace. The roasted ore was discharged into cars and carefully sampled. At the end of the experiment both systems of dust-chambers were cleaned out. The average results, after a run of six days, were as follows :—

	Ounces of Silver per Ton.
Value of raw ore	106·0
Value of roasted ore, after leaching out soluble salts,	
from Stetefeldt furnace	112·5
from Howell furnace	98·1

The difference being 14·4 ounces of silver per ton, or 13·5 per cent. of the silver in the ore. This difference represents the loss of silver by volatilization in the Howell furnace above that in the Stetefeldt furnace. That the latter must be very small is evident from the much higher value of the roasted ore compared with the raw ore. The increase in value corresponded very nearly with the loss in weight, as ascertained by muffle roasting-tests, which the raw ore suffered during roasting. In these experiments 28 tons of ore were roasted per day, and divided between the two furnaces, running them only at half capacity. In regard to the Howell furnace this had the effect of keeping the ore much longer in the cylinder than if the latter had received the full charge of 28 tons.

Subsequently the Howell furnace was kept running for ten days at full capacity, receiving the ore from 20 stamps, and the Stetefeldt furnace was supplied from another battery of 20 stamps. The results from the Howell furnace were as follows :—

	Ounces of Silver per Ton.
Value of raw ore	120·6
Value of roasted ore, minus soluble salts	115·5
Difference	5·1

or the roasted ore was 4·2 per cent. lower in value than the raw ore. The results from a forty days' run of the Stetefeldt furnace were as follows :—

	Ounces of Silver per Ton.
Value of raw ore	109·8
Value of roasted ore, minus soluble salts	115·8
Difference	6·0

or the roasted ore was 5·4 per cent. higher in value than the raw ore. This makes a difference of 9·6 per cent. between the two furnaces, and represents the loss of silver in the Howell furnace above that taking place in the Stetefeldt furnace. In comparing the loss of silver resulting in the two experiments, we have again a confirmation of the writer's theory of the influence of time. When the Howell furnace was running at half its capacity, and the ore remained longer in the cylinder, the loss in silver was 3·9 per cent. greater than in the second experiment, when the furnace was running at full capacity. The character of the Ontario ore is such that these losses are by no means astonishing. It contains nearly all the silver as fahlore, rich in antimony and arsenic, and carries a large percentage of zinc-blende. The average values of the tailings resulting from the amalgamation of the roasted ore, and the percentages of soluble salts in the latter, were practically the same for both furnaces, showing that the roasting was equally well done in each instance.

12.—*The Volatilization of Gold by Chloridizing-roasting in a Stetefeldt Furnace.*—It is a well-known fact that the loss of gold in chloridizing-roasting, using a reverberatory or Brückner furnace, may be enormous, and that it is principally a function of time. Messrs. Kuestel and Aaron record losses of from 20 to 50 per cent. The author, by chloridizing-roasting of gold-ores in a reverberatory-furnace in Mexico, suffered losses from 53 to 86 per cent. The ore contained 0·2 to 0·9 ounce of gold per ton. Its gangue was magnetite, with a small amount of quartz and garnet; the gold-bearing sulphides were copper pyrites (from 3·5 to 7 per cent.) and iron pyrites (from 3 to 22 per cent.). That not any more gold than silver is lost by chloridizing-roasting in a Stetefeldt furnace, is shown by the following statement.

At the Lexington mill, Butte, Montana, a silver-ore that contains a considerable amount of gold is subjected to a chloridizing-roasting in the Stetefeldt furnace. The ore is composed of silver-bearing iron pyrites, zinc-blende, galena, and some native silver, with quartz-gangue, sometimes replaced by silicate of manganese. Antimonial and arsenical

silver-minerals are absent, and native gold is not visible. From the character of this ore we can safely infer that it will lose less silver in roasting than Ontario ore, and that in a Stetefeldt furnace this loss must be exceedingly slight. Now if, in the roasted ore, the proportion of silver and gold remains the same as in the raw ore, it follows that also the loss in gold must be very small. The average of about 600 samples, taken at the Lexington mill from October, 1883, to August, 1884, and compiled from the monthly averages of the assayer's report, is as follows:—

	Silver. Ounces per Ton.	Gold. Ounces per Ton.
Value of raw ore	45·9 ...	0·77
Value of roasted ore, minus soluble salts ...	50·0 ...	0·84
Increase in value	4·1 ...	0·07
„ „	8·8 per cent.	9·1 per cent.

From this statement it would appear that the loss of gold in chloridizing-roasting in the Stetefeldt furnace is somewhat less than that of silver. The difference, however, in the increase of value between silver and gold is only 0·3 per cent., and within the limits of errors in sampling and assaying.

13.—*The Chlorination of Silver by Roasting in the Stetefeldt Furnace.*—The so-called chlorination-tests are made by treating a sample of roasted ore with a solution of sodium hyposulphite and assaying the tailings. In the following some of the older statistics on chlorination are given that answer the purpose just as well as more recent ones, which latter the author does not happen to have on hand.

Surprise Valley mill, Panamint, California.—Chlorination-tests made from September 19th to October 23rd, 1875; certified by Mr. C. Weberling, assayer and superintendent. In 96 samples, the following percentages of chlorination occur:—

Per Cent.	Times.	Per Cent.	Times.
85	1	92	18
87	1	93	24
89	1	94	26
90	3	95	12
91	7	96	3

The two low samples of 85 and 87 per cent. were caused by having a new labourer on the furnace, who had never fired it before, the regular fireman failing to be on shift.

Manhattan mill, Austin, Nevada.—Chlorination-tests made from November 1st to December 24th, 1877; certified by Mr. F. E. House, assayer. In 198 samples, the following percentages of chlorinations occur:—

Per Cent.	Times.	Per Cent.	Times.
88	7	92	28
89	28	93	15
90	49	94	—
91	68	95	3

The same mill. Monthly averages of chlorination-tests from October 1st, 1874, to September 30th, 1875; obtained from Mr. Alexander Trippel:—

	Per Cent.		Per Cent.
1874.—October	90·3	1875.—April	90·8
„ November	89·2	„ May	91·6
„ December	91·1	„ June	92·8
1875.—January	89·8	„ July	92·3
„ February	90·0	„ August	91·8
„ March	90·6	„ September	91·5

Ontario mill, Park City, Utah.—Chlorination-tests during July, 1881; copied from the assay-book; Mr. Joseph E. Galigher, superintendent of the mill; Mr. C. W. Watkis, assayer. In 58 samples, the following percentages of chlorinations occur:—

Per Cent.	Times.	Per Cent.	Times.
88	1	92	13
89	1	93	21
90	2	94	9
91	8	95	3

The same mill. Average chlorination-tests from March to September, 1882, according to the Russell method; furnished by Mr. E. H. Russell, assayer:—

	Per Cent.		Per Cent.
1882.—March	92·0	1882.—July	93·0
„ April	91·3	„ August	92·2
„ May	92·9	„ September	91·4
„ June	92·5		

The same mill. Chlorination-tests, according to the Russell method, from October 12th, 1882, to January 1st, 1883; furnished by Mr. E. H. Russell, assayer. In 131 samples, the following percentages of chlorinations occur:—

Per Cent.	Times.	Per Cent.	Times.
87	1	93	46
90	2	94	33
91	10	95	9
92	30	96	—

Lexington mill, Butte, Montana.—Mr. A. Wartenweiler, superintendent; Mr. G. C. Carson, assayer; official report. The Lexington ore contains more or less native silver, hence the results of amalgamation are a better standard for the work of the furnace than chlorination-tests:—

Month.	Furnace. No.	Chlorination. Per Cent.	Left in Tailings. Per Cent.
1882.—December	1	82·9	10·0
„ „	2	85·1	11·8
1883.—January	1	85·9	9·9
„ „	2	85·9	10·8
„ February	1	86·9	7·4
„ „	2	86·0	8·5
„ March	1	89·9	7·8
„ „	2	90·1	8·9
„ April	1	92·6	6·1
„ „	2	92·5	6·5
„ May	1	93·8	5·5
„ „	2	94·6	5·3

If chlorination-tests are made separately on samples of roasted ore immediately after discharging the same from the shaft and from the dust-chambers, they show a great difference in favour of the dust, provided the ore is of such a character that it requires heap-roasting on the cooling-floor. The reason is that the ore in the dust-chambers has already undergone a heap-roasting, because it is allowed to accumulate and remain there for many hours before a charge is drawn. On the whole, however, the ore roasted by the auxiliary fire-place shows slightly higher chlorinations than the ore roasted in the shaft, *i.e.*, after heap-roasting is finished.

14.—*Distribution of Roasted Ore in different Parts of the Stetefeldt Furnace.*—The distribution of the ore in different parts of the furnace depends: (1) On the fineness of crushing; (2) on the character of the ore; (3) on the draught; and (4) on the quantity of ore going to the furnace. It can be easily seen how these conditions affect distribution. As a rule no statistics regarding this question are taken in mills. The author, however, made some observations at the Ontario mill. For a period of ten days the ore discharged from the shaft, the flue below the auxiliary fire-place, the first six dust-chambers, and the last six dust-chambers, was weighed, and the results are recorded in the table below:—

	Shaft.	Flue below Auxiliary.	First Six Chambers.	Last Six Chambers
If the value of the raw ore be reckoned at 100, the value of the roasted ore, minus soluble salts, was	89	109	114	112
If the total weight of the roasted ore be reckoned at 1,000, it was distributed as follows:	317	561	112	10
If the silver in the roasted ore be reckoned at 1,000, it was distributed as follows:	306	571	114	9

The ore, at the time, contained a considerable percentage of sulphides, which made it necessary to use a strong draught in roasting.

15.—*Labour.*—One man, in an 8 hours shift, attends to the firing and general supervision of a Stetefeldt furnace, irrespective of the quantity of ore roasted. In case gas-fuel is used, he charges and takes care of the Taylor gas-producer. The labour necessary for discharging, and manipulating the roasted ore on the cooling-floor, is, of course, dependent on the output, and is proportionately the same as with other roasting-furnaces.

16.—*Fuel.*—The quantity of fuel consumed, per ton of ore, is principally a function of the number of tons roasted per day, *i.e.*, it rapidly decreases with increase of tonnage; hence the economy of using furnaces of large capacity. Another, but much less effective element, is the percentage of sulphur in the ore, *i.e.*, oxidized ores require more fuel than ores containing pyritic minerals. The table below gives a good illustration of this :—

Furnace at	Tons of Ore Roasted per day.	Coal Consumed in the Taylor Producer per Ton of Ore. Pounds.	Wood Consumed per Ton of Ore. Cords.
Ontario mill...	40	225 ...	0·19
Marsac mill	70	142 ...	0·13
Aspen mill	90	117 ...	—

The last column refers to the consumption of wood before gas was introduced.

The coal consumed at the Ontario and Marsac mills comes from the same mine; that used at Aspen has practically the same caloric effect as the coal consumed at the former mills.

The ore at the Ontario mill has been roasted at a higher temperature after the introduction of gas than was formerly the case with wood. Of the ores roasted, the Aspen ore is the highest, and the Marsac ore the lowest in sulphur.

Since the introduction of gas at the Ontario mill, a saving in cost of fuel for roasting (as compared with wood) of 2s. 4d. (56 cents) per ton of ore has been effected; and at the Marsac mill the saving is 1s. 8½d. (41 cents) per ton of ore.

In conclusion, the following facts will be of interest. The Stetefeldt furnace has roasted successfully so-called dry silver-ores of great diversity in character and richness. The ores treated have varied between 20 and 250 ounces of silver per ton. Oxidized ores, if entirely free from sulphides, require for good chlorination the addition of pyrites or pulverized sulphur. One-half per cent. of the latter, or 1 per cent. of the former, will generally effect the desired result, except when the gangue

contains carbonates of lime or magnesia which, during roasting, are converted into caustic lime or magnesia. Thus, *e.g.*, the Aspen ore,* with 11 per cent. of lime (CaO) and 4 per cent. of magnesia (MgO), requires the addition of sufficient pyrites to bring up the sulphur in the charge to 8 per cent., in order to counteract the deleterious effect of the lime and magnesia. Oxidized ores free from lime chloridize well without the addition of sulphur if they contain oxides of manganese, which was the case of the Northern Belle mill. So far as the percentage of salt is concerned, no special experiments have been carried out to determine whether the Stetefeldt furnace can chloridize silver-ores with materially less salt than other furnaces. The percentage of salt necessary for good work depends entirely on the character of the ore. The baser the ore, especially the more zinc-blende present, the greater is the quantity of salt needed. Ores in the Panamint mill have been chloridized as high as 96 per cent. with only 3 per cent. of salt, while at the Ontario mill it is found profitable to use 15 per cent. of salt.

Mr. A. G. Charleton (London) wrote that the members were greatly indebted to Mr. Stetefeldt for a very clear account of the construction of his furnace, a faithful and impartial description of its applications, and for bringing to the notice of the members various points of interest connected with its operation. In these days when reduction of working expenses and extra saving of product are objective points which metallurgists endeavour to realize, the application of producer-gas to the roasting of silver-ores, which Mr. Stetefeldt first initiated (effecting, as he stated it has done, a marked saving in cost) may be looked upon as a valuable advance in scientific achievement in this branch of the mining industry. The author refers to the employment of the Taylor gas-producer for this purpose, but according to Mr. Geo. W. Goetz,† "recent reports show that the Wellman producers work better, besides costing 50 per cent. less, than Taylor producers of equal capacity." Mr. Goetz states that Indiana and Illinois coals cannot be used in the Taylor gas-producer on account of the large size and hardness of the clinkers produced. A similar difficulty Mr. Stetefeldt states,‡ was encountered in running the Taylor gas-producers at Aspen with coal leaving light and

* The analysis of Aspen ore, given previously, refers to the pulp going to the Stetefeldt furnace, and includes the pyritic ore added.

† *Trans. Am. Inst. Min. Eng.*, vol. xxiii., page 587.

‡ *Ibid.*, page 136.

infusible ashes when employing Colorado Sunshine coal alone, and at the Marsac mill with coal mined at Coalville, Utah. For this reason the Marsac gas-producer is supplied with the dearer Rocksprings coal, and the Sunshine coal used at Aspen is mixed with two-thirds of its weight of Newcastle (Colorado) coal. The average composition of these coals (with which the Taylor gas-producers work well) is given as follows:—

	Aspen. Per Cent.	Marsac. Per Cent.
Water	2·0	7·0
Volatile matter	37·4	36·0
Fixed carbon	44·8	53·3
Ash	15·7	3·5

Mr. Stetefeldt also says that "for insulating the gas-tubes in the Ontario mill plant, they will be first covered with thin corrugated iron, over which a coating of asbestos-magnesia will be spread." Troughs of sheet-iron filled with mineral wool were first used at the Marsac and Aspen mills for cheapness. Provision has to be made for removing tar and soot from the pipes, and Mr. Stetefeldt seems to be of opinion that there is little fear of over-heating or burning the pipes if spiral-weld steel-tubes are used in place of riveted sheet-iron. Mr. G. W. Goetz and Mr. W. H. Blauvelt, on the other hand, recommend the use of pipes fitted with a refractory lining as being superior in their opinion to spiral-weld steel-tubes; alleging in favour of the former that a proper arrangement of draught permits the whole system to be burnt out perfectly clean, with but little delay and no labour; whilst the lining of the pipe largely prevents strains from expansion and contraction, and diminishes very greatly the need of frequent repairs. The weight of such pipes is certainly, however, an objection, nor is it practicable to line them if of small diameter. In the somewhat exceptional case of an ore requiring to be submitted to a long and gradually increasing temperature, before salt is added, for chloridizing-roasting, difficulties are met with in employing a furnace of the Stetefeldt class, and he (Mr. Charleton) scarcely thought that it would be likely to be successful in roasting heavy pyritic ores preliminary to other treatment, but it is undoubtedly very effective for the chloridizing-roasting of silver-ores, preparatory to lixiviation or amalgamation, if they did not contain over 8 or 9 per cent. of sulphur. He (Mr. Charleton) agreed with Mr. Stetefeldt's remarks that it was not necessary to crush ores finer for roasting in a Stetefeldt than in other types of furnace, and if the silver minerals in an ore are of no great density, and are decrepitated by heat, the ore could be crushed coarse without endangering the subsequent roasting; but if the principal silver

minerals are of great density and did not decrepitate, it was of great importance to crush the ore fine. The difference between crushing through a No. 20 as compared with a No. 40 mesh screen has been known to make a difference in the chlorination result of 27 per cent., besides taking a much longer time.

Mr. D. A. Louis (London) said that shaft furnaces had been tried for roasting pyritic ores, but had never proved very successful. Firstly, the contact was generally not sufficiently long; in the Gerstenhöfer furnace (still, or at least until recently, in use at Swansea), however, the contact was comparatively prolonged, the operation of roasting in it was therefore slow, and its chief use was to reduce the percentage of sulphur to about 8 per cent.; the products of combustion in this case being suitable for the manufacture of sulphuric acid. With most other shaft furnaces not only was the contact too limited, but the atmosphere was generally so charged with products of combustion from the fuel that it was rendered very ineffectual as a roasting atmosphere, and therefore not only was the roasting of the ore very imperfect, but also the gaseous products of the roastings became so dilute, as regards their sulphurous contents, that they were useless for the manufacture of sulphuric acid. These remarks apply even to furnaces provided with shelves to break the fall, and thereby improve and prolong the contact of the particles of ore with the atmosphere; hence there seemed little hope of a furnace with a plain shaft of the Stetefeldt type ever being successfully used for roasting pyritic ores. It must not be forgotten that the mineral had to be finely crushed for the Gerstenhöfer furnace, that the fuel was the sulphur of the ore, and that an artificial air-supply was resorted to. The Fauvel shaft furnace for roasting pyrites had recently been described, in which provision had been made to keep the air-supply for the roasting separate from the products of combustion from the furnace fire, and it was said that this furnace had proved successful.

Mr. C. A. Stetefeldt wrote that the use of spiral-weld steel-tubes for conducting producer-gas had proved a complete success at the Marsac and Ontario mills. In the latter mill they had been in use about a year, and in the former for two years. It has been found advantageous, however, not to provide them with an insulating covering. If, during cleaning, a tube became red hot by the burning of soot, this was at once observed, and the tube was closed until it cooled down. Using this precaution, the spiral-weld tubes were very durable and required no repairs for years. Expansion and all strains were taken up by expansion-joints of simple construction. For reasons which the writer need not explain in

detail, it would have been impracticable to use pipes lined with a refractory material on account of their weight. At the Ontario mill, the introduction of gas-fuel, for drying and roasting the ore, saved about £13 per day, as compared with the cost of the wood which was formerly used.

The CHAIRMAN moved a vote of thanks to Mr. Stetefeldt for his interesting paper, which was agreed to.

Mr. John Morison's paper on "Walling and Sinking Simultaneously with the Galloway Scaffold" was then read.

WALLING AND SINKING SIMULTANEOUSLY WITH THE GALLOWAY SCAFFOLD.

By JOHN MORISON.

So far as the writer is aware no successful attempt has been made up to the present time, with the exception of the one about to be described, to wall shafts during the operation of sinking without withdrawing the men from the bottom whilst walling was proceeding.

The present paper is a record of the operation, which has been carried out successfully, of walling a shaft, 20 feet in diameter and 1,650 feet in depth, the shaft being lined from top to bottom, with the exception of small projections of hard stone under several of the walling-crib foundations. In places where the stone was quite sound, these were left in and dressed; in other places where the foundation was not so good, the foundation-cribs were underset with the under course of brickwork right up to the crib.

It will be seen from Figs. 1 and 2 (Plate VIII.) that the scaffold or cradle is suspended by four ropes in double purchase, these being 5 inches in circumference, and of Bessemer steel. One end of these ropes is made fast at the surface by attachment to a heavy screw, which serves for purposes of adjustment in the event of the ropes riding unevenly on the drums. The other end passes round the wheel on the cradle and over another wheel on the winding-frame, and thence to the crab-drum. Four drums are thus required on the crab-engine.

The part of the rope between the scaffold and the pulley on the frame is used for a guide-rope to the rider, and serves to guide the kibble up from and down to the cradle. When the kibble approaches the cradle the engineman slows until he lifts the rider upon an indiarubber buffer seated upon the top of the socket of the winding-rope. The rider is provided with a bush (Figs. 5 and 6, Plate VIII.), through which the winding-rope runs, and which also serves partially as a rest for the buffer referred to. Resting upon the cradle, where the two legs of the rider seat themselves, indiarubber buffers also surround the guide-rope to minimize as far as possible the shock of the rider landing on the cradle.

This arrangement, so far as the use of the cradle, ropes, and rider for the purpose of guiding and steadying the kibbles, was, the writer

believes, invented by Mr. W. Galloway, of Cardiff, some fifteen years ago, but walling simultaneously with sinking by means of it has not been heretofore practised, and in order to do so the cradle must be specially designed and substantially built for the purpose.

The cradle, as designed by the writer and used at Newbattle colliery, consists of a working floor (Fig. 3, Plate VIII.) and a protecting roof (Fig. 4, Plate VIII.). Between these there is ample height for men to work. The centre of the cradle contains an opening which provides space for two kibbles passing each other. This opening is fenced by sheet-iron, $\frac{1}{4}$ inch thick and $6\frac{1}{2}$ feet high, bolted to the six upright angle-bars and hangers.

The floor stage is formed by a 4 by 4 inches by $\frac{1}{2}$ inch mild steel angle-bar turned to a true circle, supported on and fastened to the bottom framing or flooring, which is constructed of 5 by 5 inches by $\frac{5}{8}$ inch steel angle-bars. The floor is covered with planking 5 inches thick.

A door or hatchway is hinged to the floor, and is raised or lowered by the block-and-tackle fastened by shackles to the door and the framing of the scaffold. The door is recessed to allow of its closing on the air-boxes and pipes. Hatchway doors are also left on the other side of the cradle to permit of the brick kibble—the arrangement of which is hereafter described—being lowered through if required.

The roof is formed of 5 by 5 inches by $\frac{5}{8}$ inch steel angle-bars, covered with $\frac{3}{8}$ inch sheet-iron plates. The framing of the roof where the suspending wheels carry the whole of the cradle, is constructed of double 5 by 5 inches by $\frac{5}{8}$ inch steel angle-bars riveted together.

The bottom and top of the scaffold are connected together by four corner steel angle-bars 5 by 5 inches by $\frac{5}{4}$ inch bolted to the top and bottom framing. Four stays are placed to the four upright corner angle-bars for the purpose of supporting and stiffening the top or roof framing. Two $1\frac{1}{2}$ inches tension-rods are secured to the double angle-bars and to the outer ring of the floor for the purpose of strengthening and carrying the floor. A sheet-iron ring, formed of $\frac{3}{16}$ inch sheet-iron, is bolted to the circular framing and forms a fence round the scaffold 18 inches high. The difference between the diameter of the pit and the upper side of this ring is about $1\frac{1}{2}$ inches, or an opening of $\frac{3}{4}$ inch exists between the brickwork and the fence. Fending-plates are bolted to the bottom of the scaffold to guide a swinging kibble through the opening in case of accident. The weight of the scaffold is about $8\frac{1}{2}$ tons, and, when loaded with bricks, lime, and workmen, the working load is about 20 tons.

As already described, the cradle is hung by four 5 inches ropes, in double purchase. In addition to these, another guide rope, made fast at the top, as previously described in the case of the other guides, and looped down the shaft, is provided. Upon this is hung a pulley, supporting the water-tank and scaffold, with two pulsometers and suction-pipes and discharge-pipes into the cistern. Valves and hoggers for running the water into the water-barrels are also provided. The double rope referred to is brought through the cradle, and the loose end is led on to one of two drums on the winding-engine. The other drum is provided with a winding-rope, and the kibble used with this rope runs with a rider, with the pump suspending-rope as a guide on each side, and supplies the scaffold with bricks, lime, etc.

Both drums on the winding-engine are clutched so that when firing shots in the bottom, the pulsometers and scaffold, etc., after being disconnected from the steam-pipe, may be hauled up out of danger. It may be mentioned that this arrangement of loading the water-barrels proved very satisfactory and economical. No baling was required, and after week-end stoppages the water was rapidly taken out. About 200 gallons per minute from a depth of 900 feet was at one time wound out of the pit-bottom for several weeks, while sinking progressed and pumps were fixed.

The mouth of the sinking-pit was covered by two pairs of folding-doors. In the case of winding water, a tank provided with wheels was run on to the doors and the water-barrel in seating itself on to the tank engaged a projection which struck open the bottom valve and discharged the water. In tipping *débris*, a shoot built of steel plates and mounted on wheels was run on to the doors between the two kibbles, so that either kibble could be tipped into it. The shoot delivered the *débris* into tipping-wagons. The kibbles, being provided with trunnions, it was not necessary to detach them from the steadiment of the guide-ropes at the top. The platform upon which the doors rested was considerably above the ground-level, in order to permit of the *débris* being put into wagons.

At the ground-level, one pair of similar doors were placed which were opened to permit of the passage of the kibble containing bricks, lime, etc., and closed whilst the kibbles were being loaded. In both cases the doors were recessed to the size of the ropes, so that they closed tightly over the guide-ropes and easily over the winding-ropes.

The arrangement for guiding the kibbles to the position of the scaffold permits of a comparatively high speed of winding, and also enables double kibbles to be used with great safety. The sinking-engine in the instance described could wind the kibble from the depth of 1,650 feet in 55 seconds.

In walling, a roll of canvas or brattice-cloth was packed between the outer ring on the scaffold and the shaft side, so that there was absolutely no opening. The hatch or doorway, where it closed against the air-boxes, pipes, etc., was also carefully packed with canvas before commencing to build the walling. Sheet-iron plates were laid over the hatchway where the brick kibble was tipped.

The bricks and lime were sent down in kibbles provided with trunnions and the material was tipped without detaching the kibble from the rope. At the top of the pit, the empty kibble was landed on to a bogey, detached from the rope, and a full kibble hung on in its place.

When walling, three bricklayers with three labourers, and a sinker in charge, were the most convenient number to work on the scaffold, and in ordinary work these workmen would build a five feet length complete.

The scaffold was considered safe from damage by shots in the pit-bottom when at a distance of 60 feet from the bottom.

Crib-beds were laid as the foundation was found suitable, and lifts were taken varying from 90 to 240 feet.

The timbering was made with cribs built of 11 by 3 inches planks fished together at the segments by double covers 11 by $1\frac{1}{2}$ inches. These were put together and marked at the surface and lowered down in segments. In soft strata, the cribs were placed $2\frac{1}{2}$ feet apart, the backing deals being 5 feet long. This arrangement, in drawing the timber, provided means of supporting loose stone, as by leaving in the backing deals, these, when the under crib was drawn, were supported by the two upper cribs—when the middle crib was drawn, by the brickwork and the upper crib—and when the upper crib was drawn support was entirely afforded by the brickwork.

In drawing timber it was found to be unnecessary to bring up the sinkers, except in very bad ground.

In forming a crib-bed, the sinkers left the stone rough hewn out, leaving the levelling and dressing to be done off the cradle. This work was also done without accident, and without withdrawing the sinkers.

It was also found possible to form pump-rooms and lodgments in the side of the shaft, by taking the scaffold to the point required and winding the *débris* with the brick kibble, and this was done in several instances, no time being lost in sinking.

The cradle was usually raised during the time when the men were changing shifts.

The folding-door permitted of the cradle passing any obstructions or tight places in the shaft, and two or three men usually rode upon it to clear it of any such obstructions when raising or lowering.

A lift of concrete coffering about 90 feet high and 28 inches thick was put in from the scaffold very conveniently. The ordinary brickwork was $10\frac{1}{2}$ inches thick.

After being fairly put to work, there was no trouble in working the scaffold.

No accident occurred through its use, although two occurred with the brick kibble-rider, which it may be useful to record. One of these occurred through the rider sticking on the guide-rope and afterwards coming down. The cause of this accident was never satisfactorily ascertained, but after its occurrence the bushes on the rider, which are of beechwood, were given more clearance, and allowed to be $\frac{1}{2}$ inch slack on the rope. The second accident was caused by some sinkers, who, whilst working in the shaft, lashed up the rider on the rope some distance above the kibble. Owing to insufficient lashing the rider fell away. On both occasions a fatal accident occurred.

The advantages which the writer has observed in the use of the cradle are as follows :—

1. It permits of quick winding with double kibbles with great safety.
2. No time is lost through the sinkers being withdrawn to wall.
3. The brickwork can be better done by skilled bricklayers and at less cost than by sinkers.
4. In forming any necessary recesses or roads off the shaft side, no delay in sinking need be incurred.
5. The suspension of a substantial structure in the shaft affords considerable protection to the men working in the pit-bottom.

With reference to the latter advantage, upon several occasions when material had dropped accidentally down the shaft, it landed on the roof of the scaffold and caused no damage ; and especially when working within a moderate distance from the bottom, the protection was found of great advantage.

The drawings (Plate VIII.) accompanying this description of the apparatus are detailed enough, the writer thinks, to render unnecessary a fuller description of the arrangements.

Mr. Henry Lawrence (Durham) said that the author of the paper was in error in assuming that the Galloway scaffold had not been previously used for sinking and walling simultaneously. He understood it had been used at the Llanbradach colliery, when Mr. Galloway was manager.

Mr. A. L. Steavenson (Durham) said that the writer of the paper was to be congratulated on the successful results he had obtained. "All's well that ends well," but he thought as a rule it was undesirable to attempt to do two things at once. The principle advocated in the paper would scarcely be applicable to shafts in which there were large feeders of water. No doubt provision was made for the removal of powder-fumes and smoke from the shaft by proper ventilation, but this was not described in the paper.

The President suggested that a comparison of the time occupied in sinking and walling by the ordinary process and by that described would be of interest. He thought care should be taken with the new system to avoid accidents.

Mr. W. B. Scott (H.M. Inspector of Mines) said that in addition to the comparison suggested by the President there were one or two other points of interest which might have been discussed with the paper. He remembered that twenty-one years ago in Staffordshire, a rider was constantly used for steadying the kibble. The method of covering a shaft with hinged doors was, he thought, old-fashioned and awkward as compared with the usual method of a sliding platform. The author stated that "crib beds were laid as the foundation was found suitable, and lifts were taken varying from 90 to 240 feet." Perhaps the author could afford further information on this question. He thought it would have been possible to avoid the two fatal accidents by putting a stop for the rider.

Mr. Henry Lawrence thought he could answer the question of the last speaker as to the crib-beds. He took Mr. Morison to mean that a crib was put in where they could get a good sound bed for it—a good bed of rock—they then proceeded to wall for 90 or 100 feet, which was called a lift, before putting in another crib.

Mr. Spruce (Tamworth) thought that there must be some mistake as to fixing the cribs even 90 feet—not to say 240 feet—apart. In his long experience he had never seen any ground which could be left unprotected for any such length. The principle of using a rider with the kibble was not so new as the author of the paper seemed to think; he had used a similar arrangement as far back as 1850.

Mr. H. Lawrence said it would be interesting to know at what distances apart Mr. Spruce would place the crib-beds when walling. When putting in cast-iron tubbing, it sometimes happened that wedging cribs were placed 50 or 100 feet apart.

Mr. Spruce replied, as often as necessary.

Mr. W. B. Scott said that an accident in South Wales was due to a long length of the shaft being left without walling, and so allowing a mass of rock to fall out. He had seen ground that required crib-beds being placed at intervals of only four feet.

Mr. Henry Lawrence remarked that the accident in South Wales was supposed to have been caused by a blown-out shot. He had visited the colliery, and was fully acquainted with the particulars.

Mr. W. B. Scott said he understood that the men were killed by a stone falling from the side of the shaft. In any case, the closer they kept the casing to the back of the sinkers the better.

Mr. John Morison wrote that he believed that the statement made in his paper was quite correct, that the operations recorded were the first instance of sinking and walling simultaneously without withdrawing the men from the pit-bottom. Possibly experiments may have been entered into, but no suitable plant had hitherto been brought under notice in the *Transactions* of The Federated Institution of Mining Engineers. The criticism that "all's well that ends well" might be taken to express considerable doubt in Mr. Steavenson's mind as to the safety of the process; but the writer maintains that the arrangement, so far from being a source of danger formed a considerable protection to the sinkers, and that there was absolutely no danger of walling material falling to the pit-bottom. The total quantity of water encountered in the shaft in question was 500 gallons per minute down to a depth of 1,020 feet, and although the quantity was not large the depth of water-bearing strata was considerable, and the writer thinks that the arrangement would be equally applicable with large quantities of water. The ventilation of the sinking shaft was effected by means of a forcing-fan blowing air down pipes into the pit-bottom, and by the exhaust air from a small air compressor. The writer is aware, as noted by Mr. Scott, that apart from the application of riders along with the general arrangement described in the paper, there was no special novelty. The comparative advantages of different methods of covering the shaft are of course dependant upon the constructive details, and it is therefore hardly fair criticism to classify any arrangement as old-fashioned and awkward from the fact of the construction proceeding on any particular principle. It would have prolonged the paper, which was specifically limited to the description of the walling arrangements, to an inordinate extent to describe in detail the whole of the sinking arrangements. The double-hinged doors were very rapid in use, and their safety is best vouched for by the fact that they were used during the whole time of sinking without accident. The statement that "crib beds were laid,"

etc., was correctly construed by Mr. Lawrence, in so far as he explained that a crib was put in when a good sound bed was got for it. The writer is aware that unusually long lengths of walling (taken from crib to crib) were used in the shaft referred to, and he is of opinion that with a good system of timbering very bad ground may be securely left between the crib beds. The drawings (Plate VIII.) accompanying the paper give full details of the timbering, in anticipation of questions upon this point, and the writer holds that with such a system a shaft can not be described as unprotected. The writer did not refer to the comparative times and costs of walling and sinking by the process described, and by the usual process, it being obvious that the difference or time saved is practically the whole of the time usually occupied in walling, seeing that it is never necessary to withdraw the sinkers. The walling will, the writer thinks, be done cheaper by skilled bricklayers than by sinkers, and the complete nature of the apparatus is also favourable to such a result, otherwise the cost of walling would be the same whether the walling was done with the sinkers in the bottom or in the ordinary way. Owing to the saving of time it is obvious that there must be a considerable saving in the standing expenses of the pit-sinking, such as fuel and wages. In every instance the saving in cost would vary, and the amount would be dependant upon the establishment expenses. The cost of more extensive timbering than usual would have to be set against any such saving, although it may be questionable whether similar timbering is not also necessary with shorter lifts of walling. But with a saving in time equal to the whole time usually employed in walling, and which, the writer thinks, may be taken on an average, at one-sixth of the total time of sinking, the saving, especially where there is a heavy establishment, must be very great. In estimating the exact saving, to be obtained in any instance the writer would base the saving on establishment expenses, through shortening of the time occupied, and upon any further contingent saving due to the time saved, and would estimate the cost of walling *per se* to be equal either way.

The PRESIDENT proposed a vote of thanks to the author for his interesting and valuable paper, which was agreed to.

DISCUSSION ON MR. HUGHES' PAPER ON "PHOTOGRAPHY IN MINES."*

The PRESIDENT said that to anyone desirous of taking photographs underground, the paper would be found of great value. Now that the methods of photography were so much improved, excellent pictures could be made of underground workings by ordinary operators.

Mr. M. WALTON BROWN said the difficulty of underground photography was not so much in the manipulation of the apparatus, dry-plates, etc., but in obtaining effective lighting of the objects being photographed.

Mr. A. L. STEAVENSON said that his experience had not been large, but he had found photography in mines of considerable value, and the process was very simple so long as the lights were kept well behind the lens, and ample reflectors were provided. It was, perhaps, somewhat difficult to ascertain the precise quantity of magnesium to be burned in producing the actinic rays.

DISCUSSION ON MR. W. S. GRESLEY'S PAPER ON "SPONTANEOUS COMBUSTION IN COAL-MINES."†

Mr. S. SPRUCE thought it would be found that the seams most subject to gob-fires contained some moisture in the coal. He would like to make a few remarks by way of explanation in regard to the discussion which followed the reading of a paper on this subject two years ago.‡ Unfortunately he was unable to be present at the meeting when his remarks were read, but in the discussion the then President said he did not understand an observation made with reference to taking out 1,400 tons for each foot per acre,§ reducing the liability on the part of the seam to produce gob-fires. The President thought this might mean that nothing would be left to fire, and this was precisely his explanation. Pit fires might occur in the roof or in the floor, but his observations—if he were in order in referring to them—were made entirely in reference to gob-fires and not to fires which might occur otherwise. He was reminded of fires occurring in mines that were not moist, and he had referred to these in his paper‖—one that occurred by the side of roads in the thick coal-seam of South Staffordshire. He thought, generally speaking, that if attention was paid in the direction which he had indicated in his paper—to careful packing and the removal of small slack from the mine—gob-fires would be of much rarer occurrence than they had

* *Trans. Fed. Inst.*, vol. vii., page 164. † *Ibid.*, page 206. ‡ *Trans. Fed. Inst.*, vol. v., page 20. § *Ibid.*, page 28. ‖ *Trans. North Staffs. Inst.*, vol. viii., page 38.

unfortunately been hitherto. He would like to make another remark; there seemed to be a little contention about turning the ventilating current upon a gob-fire, and in the previous discussion Mr. Binns thought that he (Mr. Spruce) seemed to think they were going to take a volume of air and pour it upon the gob.* He meant that he did not think any additional air passed through the mine would assist in staying an actual gob-fire. Ventilation must of course go on and regard must be had to the lives of the workmen employed and for the safety of the mine, but its action was only to increase the fire.

Mr. W. F. Howard (Chesterfield) said that Mr. Binns had thoroughly explained that the admission of air he advocated was before the gob-fire took place, but afterwards all air should be kept from the fire.

Mr. D. A. Louis (London) stated that at the recent meeting of the British Association Mr. Thomas had drawn attention to a possible relationship between the hygroscopicity of the coal and its liability to spontaneous combustion, and he (Mr. Louis) was of opinion that any such relationship would more probably be found to be due to the hygroscopicity being in a way a measure of the purity of the coal, than to its indicating the presence of hygroscopic compounds capable of giving rise to spontaneous combustion. It should be remembered that *inter alia* the question of ventilation in its bearing on spontaneous combustion was discussed last year at the Glasgow meeting, and many points now raised was then considered.

The President thought it might be well in the future to direct their attention to the causes of these gob-fires, for if they knew the real causes they would be better prepared to take steps for their prevention, but at present they seemed to be involved in considerable doubt and mystery.

STUDENTS' MEETINGS.

The Secretary announced that the Council were making arrangements for Students' Meetings, limited to members under twenty-five years of age, that a prize would be offered for the best paper on a chosen subject, and that further particulars would be announced in due course. He invited written suggestions from members as to the place and date of the first meeting, which would be held during the course of next year.

The following paper by Mr. Morgan W. Davies on "Timber Bridges and Viaducts" was taken as read:—

* *Trans. Fed. Inst.*, vol. vi., page 412.

TIMBER BRIDGES AND VIADUCTS.

By MORGAN W. DAVIES.

The subject of this paper, it may be suggested, diverges widely from the conventional category of contributions to the Institution's proceedings, which although embodying a comprehensive record of experience and research, have so far been devoted to topics more closely allied with mining. It must, however, be borne in mind that the duties of a mining engineer are daily becoming more extended, and by reason of an ever-growing tendency in every branch of industry to concentrate and unite small undertakings into larger ones, the scope of the administration must necessarily become more extended. It, therefore, frequently happens that the administrative head of a large mining establishment is not only responsible for the technical supervision of the mining operations, but also for the direction and control of the general *ensemble* of the undertaking, often including the laying out, construction, and maintenance of many miles of private railways, roads, bridges, and other accessory work.

In view of such contingencies it is thought that an occasional paper of this nature may be of interest, if only for the purposes of reference, because it has not fallen to the lot of every mining engineer to be associated with works of the kind.

Again it may be advanced that to advocate the construction of timber bridges at the present moment, when iron and steel are being so rapidly substituted for other materials in almost every structural work, is the outcome of a very antiquated idea and in effect putting back the hands of the clock fifty years. While fully recognizing the permanency of structures built of iron and steel and appreciating the various qualities and forms in which those materials are being manufactured and shaped for all constructive purposes on the one hand, and acknowledging on the other hand the more perishable nature of timber structures, one must admit that there are instances daily arising where the comparative advantage of an iron or steel bridge over a timber bridge is not so much the question as to have a timber bridge or no bridge at all. This is especially true in regard to colliery railways where the works are not expected nor required to be of so permanent or substantial a character, or in connexion with the development of foreign railways frequently

passing through localities where timber is available in abundance. The duty and instinct of an engineer, under such circumstances, should be to utilize in the best manner the resources at his disposal, and to make a good job of whatever materials he may have at hand. Of all constructive materials there is probably none that lends itself so readily to every purpose as timber. It can be converted to use from the raw state and put together by comparatively unskilled hands, and if judiciously employed and proportioned for the duties it has to perform whether alone or in combination with iron or steel it makes a good strong structure.

It is a well-known fact, borne out by ample experience, that timber structures if built of selected and well-seasoned wood and properly cared for will last thirty or forty years, in proof of which it may be cited that many of the timber bridges and viaducts put up by that eminent engineer, Mr. Brunel, on the Great Western Railway from forty-five to fifty years ago are still in existence, and efficiently serving the requirements of the present day traffic, notwithstanding the fact that it is considerably heavier having regard to weight of rolling stock, etc., than that which they were originally intended to carry.

The timbers used for constructive purposes in this country are pine or fir imported principally from the Baltic ports and from North America. The Baltic timbers are known by the ports from which they are imported, viz., Stettin, Dantzig, Riga, and Memel. These timbers are procurable in lengths up to 50 feet, and from 15 to 17 inches square. The American timbers are red and yellow pine, which are principally imported from Quebec. They may be had in balks up to 50 feet in length, but not exceeding 14 inches square. Of all these timbers long-leaf yellow pine of mature growth is beyond a doubt the best timber for bridge-building that can possibly be obtained, but unfortunately it is now very scarce since all the primeval forests have been cut down, and there is nothing but young timber left available.

Pitchpine, which is derived from the Southern states of North America, and imported from Pensacola and Mobile, is obtainable in abundance to almost any dimensions, ranging up to 80 feet in length, and to 20 and 22 inches square. Pitchpine when new is a very fine timber, but with age, and as the resin dries up, it becomes very brittle and it is also subject to dry rot. Notwithstanding these defects it is largely used in bridge-building.

Oak is used in small quantities where the strain it has to resist is one of compression, such as in joggles, keys, wedges, distance-blocks, etc.

The different timbers essentially vary in strength and their capabilities of resisting the several strains to which they may be subject. The subjoined table, compiled from different authorities, sets forth their various resisting properties, weights, and specific gravities:—

Description of Timber.	Specific Gravity.	Weight per Cubic Foot.	Tensile Strength per Square Inch.	Crushing Strain per Square Inch.	Transverse Strength.
			A.	B.	C.
		Lbs.	Lbs.	Lbs.	Lbs.
Red pine	0·512	32·00	10,500	5,395	483
Yellow pine ...	0·437	27·25	10,500	5,375	474
Pitchpine	0·682	42·50	10,500	6,790	495
Larch	0·622	39·00	7,000	3,201	557
Riga fir	0·480	30·00	9,000	5,400	530
Dantzig fir ...	0·708	43·50	9,000	5,400	611
Memel fir	0·553	34·50	9,000	5,400	545
Spruce	0·555	34·50	10,000	6,499	465
Oak, English ...	0·748	46·50	9,000 to 15,000	6,484	710
Oak, Canadian ...	0·802	50·00	10,000	4,231	572

In the above table, the figures set forth in column A represent the force in lbs. per square inch required to tear asunder a beam in the direction of its length, and column B similarly sets forth the force that would compress a pillar or other piece of timber in the direction of its length, until it ultimately failed by the crushing of the material.

Column C sets forth the force whether in the form of a distributed or concentrated load on a beam supported at both ends, that would produce rupture or cause the beam to break across the grain of its fibres.

With these data the breaking weight of a beam of any of the timbers named in the table can be easily calculated by the following simple rules:—

Let B W = breaking weight in pounds.
L = length between supports in feet.
B = breadth in inches.
D = depth in inches.
A B and C = constants given in columns A B and C of the table.

Rule.—To find the weight that would break a rectangular beam when applied at the centre, the beam being supported at the ends—

$$\text{B W} = \frac{\text{B} \times \text{D}^2 \times \text{C}}{\text{L}}.$$

E.G.—What weight applied at the centre of a yellow pine beam 10 feet long between supports and 8 inches wide by 12 inches deep would break it?—

$$\text{B W} = \frac{8 \times 12^2 \times 474}{10} = 54{,}604{\cdot}8 \text{ lbs.}$$

In the case of a distributed load, the weight that would break a beam would be double that of a load concentrated at its centre and the rule would be—

$$B\ W = \frac{B \times D^2 \times C \times 2}{L}.$$

Having regard to the resistance of timber to compression in the direction of its length; its power of resisting such strains depends upon the proportion of its length to its cross-sectional dimensions. A long pillar, under an excessive load, will first bend and then break at the middle in precisely the same way as it would under transverse strain, whereas a short pillar would fail by the crushing of its fibres alone. The proportion between the length of a pillar and its cross-sectional dimensions is therefore a matter of vital importance.

To ascertain the strength of pillars of medium lengths

Let B W = breaking weight in pounds.
a = area of cross section.
B = constant in column B of table.
L = length in feet.
T = least side or thickness.

$$\text{Then } B\ W = \frac{B \times a}{1{\cdot}1 + \frac{L^2}{2{\cdot}9 \times T^2}}.$$

E.G.—What load would break a pillar of Memel fir 12 feet long and 6 inches square?

$$B\ W = \frac{5{,}400 \times 36}{1{\cdot}1 + \frac{144}{2{\cdot}9 \times 36}} = \frac{194{,}400}{2{\cdot}479} = 78{,}413 \text{ lbs.}$$

The breaking weights calculated by the above formulæ should, whether applied in compression tension or transversely, be ten times the calculated maximum stresses or loads in any member of the bridge, because the strength of wood varies very much in different specimens, and the experiments from which the values given in the table are deduced were made with selected pieces. This margin is called the factor of safety.

Having thus explained in simple form the mode of calculating the breaking weight of beams of the different timbers ordinarily used for bridge-building in this country under such normal conditions of loading as would occur in the case of a bridge, it now remains to furnish rules and examples by which the strains on the different parts can be estimated, and to apply these rules to the proportioning of every part to the strain it has to bear. The strength of a bridge is the strength of its weakest part, and any unnecessary accumulation of material does not in any way add to its strength, but on the contrary detracts from it by reason of the additional weight imposed.

The examples given in the drawings are all selected from actual practice, and in two instances they represent, with slight modifications, structures designed by the author. It has been the author's aim to show the various parts in sufficiently full detail to enable the drawings to be worked from, and as such it is hoped they may be found useful.

Example No. 1.

The illustrations (Figs. 1, 2, 3, 4, and 5, Plate IX.) represent the most simple form of bridge, consisting of a series of longitudinal timbers, supported at different points, and carrying a single line of railway. The spans, five in number, are 20 feet each, measured from centre to centre of piers. Dead or uniform load, 5 cwts. per foot run ; live or variable load, 2 tons per foot run. The girders are three in number, composed of built beams, the two outer girders being 26 inches by 8 inches, and the central girder 26 inches by 15 inches.

Principles of Calculation.

The maximum load that can come upon any one span will be 2·25 tons per lineal foot, which, multiplied by the span, will give a distributed load of 45 tons or a concentrated central load of $\frac{45}{2} = 22{\cdot}5$ tons. This weight, which is to be carried on two rails spaced 5 feet apart from centre to centre, one half or 11·25 tons on each rail, will be supported by the three girders in proportion to the respective reactions of the load upon its supports.

Thus the proportion supported by each of the outside girders will be $\frac{11{\cdot}25 \text{ tons} \times 2{\cdot}5 \text{ feet}}{5{\cdot}5 \text{ feet}} = 5{\cdot}11$ tons, and by the central girder $\frac{11{\cdot}25 \text{ tons} \times 3 \text{ feet}}{5{\cdot}5} \times 2 = 12{\cdot}27$ tons.

The maximum weights to be carried by each girder are therefore 12·27 tons by the central girder, and 5·11 tons by each side girder. It is now required to determine what cross-sectional dimensions a Memel fir beam should have to carry this load with a factor of safety of 10. The breaking weight of the beam would thus be 12·27 tons × 10 = 122·7 tons, or 274,848 lbs. Assuming the breadth of the girder = B to be 15 inches then

$$D^2 = \frac{B\,W \times L}{B \times C} = \frac{274{,}848 \times 20}{15 \times 545} = 672, \text{ and } D = 25{\cdot}92 \text{ inches.}$$

The actual depth of the girder in the drawing is 13 inches by 2 = 26 inches.

Having regard to the side girders it is needless to calculate their breaking weight because they are, in proportion to the load they have to carry, wider and stronger than the central girder. They have been given

the same depth as the central girder for the sake of uniformity, and it has been necessary to give them an additional breadth to that actually required to bear the strain due to the load upon them for the sake of giving them the necessary stiffness, failing which they would be subject to lateral flexure.

It is now required to determine whether the strength of the piles or columns supporting the structure are sufficient to resist the strain upon them. In this instance again the central pile has to support the greatest load, the proportions being: Weight supported on central pile = 24·54 tons; weight supported on each side pile × 2 = 20·44 tons; total weight of one span = 44·98 tons. The piles are 12 inches square, and the length between braces is taken at 8 feet.

Then $$B\,W = \frac{5{,}400 \times 144}{1{\cdot}1 + \frac{64}{2{\cdot}9 \times 144}} = \frac{777{,}600}{1{\cdot}253}.$$

B W = 620,590 lbs., and safe load = 62,059 lbs. or 27·7 tons, as against 24·54 tons, the actual load.

It is here supposed that the pile has been driven well home, and capable of carrying its intended load with safety. This can be determined by the following formula (Sanders'):—

Let D = set of pile by last blow in inches.
H = height fallen through by ram in inches.
L = safe load which the pile will bear in lbs.
W = weight of ram in lbs.

Then $$L = \frac{W\,H}{8\,D}.$$

The estimated quantities of materials in this bridge are as under:—

	£	s.	d.
2,061 cubic feet of timber, at 3s.	309	3	0
30 cwts. bolts, nuts, spikes, etc., at 12s.	18	0	0
18 pile-shoes (steel), at 15s.	13	10	0
12½ cwts. cast iron in pile caps, at 6s.	3	15	0
Total cost of bridge	£344	8	0
Cost per foot run	£3	8	10

Example No. 2.

In this instance the illustrations (Figs. 6 to 10, Plates IX. and X.) represent a trussed bridge in which the main beams are aided by two struts abutting against the piers or points of support, and a straining beam.

There are three spans of 36 feet each, and the load to be carried is the same as in example No. 1, viz.:—dead or uniform load, 5 cwts. per foot run; live or variable load, 2 tons per foot run.

Principles of Calculation.

The span is divided into three sections, as shown in Fig. 6 ; and the load when uniformly distributed is carried to the points of support in the following manner :—W^1 and W^4 are respectively carried directly by the piers. A C and A″ C″ and W^2 and W^3 are respectively carried and transmitted to the piers by the struts C B and C″ B″.

The main beam may therefore be treated as a beam supported at the four points A, B, B″, and A″, and the maximum bending moment will occur at the middle of either span, that is to say, at the points M′, M″, and M‴. At M″, the beam has the advantage of the support afforded by the straining beam B′ B″, so that the weakest points will be at M′ and M‴.

The maximum strain that can come upon the section A B or B″ A″ will be 27 tons uniformly distributed, or $13\frac{1}{2}$ tons concentrated at the points M′ or M‴.

The load of $13\frac{1}{2}$ tons is supported by three girders spaced 5 feet apart from centre to centre, and, as the rails upon which the load is directly carried are also 5 feet apart from centre to centre, the central girder will carry one-half of the load or 6·75 tons, and each of the side girders one-quarter or 3·375 tons.

It is therefore required to determine the dimensions of a square beam of Memel fir to carry a concentrated load of 6·75 tons, which, with a factor of safety of 10, is equivalent to a breaking weight of 67·5 tons or 151,200 lbs. The length, being one-third of the span, $= \frac{36}{3} = 12$ feet.

The square dimensions $= \sqrt[3]{\frac{151{,}200 \times 12}{545}} = \sqrt[3]{3{,}329} = 14{\cdot}78$ inches, say 15 inches square. The central beam may thus be 15 inches square and each of the side beams 15 inches by $7\frac{1}{2}$ inches, say 15 inches by 8 inches.

It is next required to determine the strain upon the struts C B and C″ B″, and in this instance again the central strut will be taken. The strain on a strut is the weight it carries multiplied by the cosecant of the angle of inclination to the horizon $= \frac{\text{weight} \times \text{C B}}{\text{A C}}$.

The weight carried by the central strut C B is one-half of the distributed load on the section M′ M″ = 13·5 tons. The length of the strut measured along its axis is 13·4 feet, and the strain will be

$$\frac{\text{C B} \times 13{\cdot}5}{\text{A C}} = 30{\cdot}17 \text{ tons or } 67{,}580 \text{ lbs.}$$

To resist a compressive strain of 67,580 lbs. with a factor of safety of 10, the dimensions of a Memel fir beam should be $\frac{67,580 \times 10}{5,400} =$ 125 square inches, or about $11\frac{1}{4}$ inches square, say 12 inches square, or for the central beam, which is 15 inches wide, a nearly equivalent section 15 inches by 10 inches, and for the two side girders 10 inches by 8 inches.

It is next required to determine the dimensions of the straining beam B B″, the length of which is 12 feet. On the central beam the weight, acting at the head of the strut producing strain in the straining beam, is 13·5 tons, and the strain is this weight multiplied by the cotangent of the angle of inclination of the strut to the horizon

$$= \frac{\text{A B} \times 13{\cdot}5}{\text{A C}} = \frac{12 \times 13{\cdot}5}{6} = 27 \text{ tons or } 60,480 \text{ lbs.}$$

This strain of 60,480 lbs. is partly tension and partly compression under different conditions of loading, and inasmuch as timber is not able to resist so great a compressive strain as a tensile strain, the calculation of the dimensions of the beam will be for a compressive strain with a factor of safety of 10.

Dimensions of beam $= \frac{60,480 \times 10}{5400} = 113$ square inches, which is nearly equivalent to the dimensions of the struts; but, for the sake of symmetry, the straining beam and struts are similarly proportioned, viz., central straining beam 10 inches by 15 inches, and the side beams 10 inches by 8 inches.

The dimensions of the floor beams must again be determined, the distance between supports, that is to say the distance from centre to centre of the girders, is 5 feet, and inasmuch as the distance between the rails is 5 feet each floor beam will carry its maximum load at two intermediate points situated mid-way between each point of support.

The floor beams are spaced 3 feet $1\frac{1}{2}$ inches or 3·125 feet apart, and the total load on each floor beam $= 3{\cdot}125 \times 2{\cdot}15$ tons, the maximum load per lineal foot $= 7{\cdot}03$ tons. The portion to be borne by each half of the floor beam will thus be 3·51 tons or 7,862 lbs. The dimensions of a square Memel fir beam, 5 feet long between supports to carry a concentrated load of 7,862 lbs. with a factor of safety of 10, would be

$$\sqrt[3]{\frac{78,620 \times 5}{545}} = 8{\cdot}96 \text{ inches (say 9 inches).}$$

The dimensions adopted are 9 inches by 10 inches, the extra inch in depth being allowed for notching down the floor beams 1 inch on the main girders to give them extra rigidity. The only remaining calculation

is to determine whether the piles are sufficiently strong to carry their load, which on each pier will be $36 \times 2{\cdot}25$ tons $= 81$ tons, carried in the proportions of 40·5 tons on the central pile, and 20·25 tons on each side pile. The dimensions of the piles are 14 inches square for the two outside piles, and 14 inches by 15 inches for the central pile, because it has to support the strut which has a width of 15 inches. The greatest unbraced length is 8 feet. Taking the central pile supporting the greatest load, then

$$\text{B W} = \frac{5{,}400 \times 14 \times 15}{1{\cdot}1 + \frac{8^2}{2{\cdot}9 \times 14^2}} = \frac{1{,}134{,}000}{1{\cdot}212}.$$

$= 935{,}643$ lbs. or 417 tons, and safe load $= \frac{1}{10} = 41{\cdot}7$ tons, as against 40·5 tons the actual load, which is a sufficiently close approximation.

The approximate quantities of materials in this bridge are as under :—

	£	s.	d.
1,992 cubic feet of timber, at 3s.	298	16	0
22½ cwts. of bolts, nuts, washers, spikes, etc., at 12s. ...	13	10	0
6 pile-shoes, at 15s.	4	10	0
Total cost of timber work in bridge	316	16	0
Taking the effective span at 110 feet, the cost per foot run is	£2	17	7

The masonry abutments at each end have not been taken into account in this calculation, so that this omission would, to a considerable extent, be the cause of the difference in cost per foot run between this bridge and that illustrated in example No. 1.

Example No. 3.

The figures from 11 to 17 (Plates X. and XI.) illustrating the Soberg viaduct in Norway represent a system of timber-bridge construction introduced by Mr. Carl Pihl, engineer-in-chief to the Norwegian State railways, to whom the author is much indebted for a number of drawings and valuable information appertaining thereto. As will be seen by the drawings, these bridges, which are built of native timber in the rough state, are admirably trussed and very strongly put together. The various details are fully shown in the drawings, and it is unnecessary to supplement them with any descriptive particulars. It will therefore be expedient to proceed with the analysis of the strains, for which purpose the skeleton diagram given in Fig. 11 will serve.

Principles of Calculation.

In these trusses each span A A = A A″. Fig. 11 may be regarded as consisting of two sections A B and B A resting on their supports A B and A. It is therefore required first of all to proportion the girder A B A to the load it has to carry, in accordance with the preceding rules and examples.

Secondly, it is required to determine the stresses on the struts B C and B″ C″, for which purpose let S = the maximum strain, which in this instance will be compression, and let W = W¹ = W² = W³ represent one-half of the total load on each span, then

$$S = \frac{B\,C \times \frac{W}{2}}{A\,C} = \frac{(\sqrt[2]{A\,C^2 + A\,B^2})\,\frac{W}{2}}{A\,C}.$$

The maximum strain on the tie C C which is tension

$$= S = \frac{W}{2} \times \frac{\frac{1}{2}\,C\,C}{A\,C}.$$

The maximum tension on the inclined tie C C″

$$= S = \frac{W}{2} \times \frac{\frac{1}{2}\,C\,C''}{A\,C}.$$

Having determined the value of these stresses, the various members can be proportioned, in the manner already explained, to the several loads which they have to carry.

The approximate quantities of materials in this bridge are :—

	£	s.	d.
2,012 cubic feet of timber, at 3s.	301	16	0
26 cwts. of iron, in bolts, nuts, spikes, at 12s. ...	15	12	0
26 pile-shoes, at 15s.	19	10	0
Total cost of bridge	£336	18	0
Cost per foot run	£3	7	4

Example No. 4.

The bridge illustrated in Figs. 18 to 25 (Plate XII.), is a trussed bridge, the principle of which was introduced in the year 1840 by William Howe, an American engineer, after whom it is called to this day the Howe truss. It is beyond a doubt about the best form of combining timber and iron in bridge construction that has ever been devised, and no better railway bridge can be built of timber, for spans up to 150 feet. It is a simple truss, consisting of chords, ties, and braces, the chords and braces being of timber and the vertical web-members or ties of iron.

The strain on the chords, resolving itself into compression on the upper chord and tension on the lower chord, is greatest at the centre of the span, and diminishes towards the ends. At the centre it equals $\frac{W\ L}{8\ D}$.

Here W = total weight of bridge and load.
L = length of span in feet.
D = depth of truss from centre to centre of chords.

The strains on the ties and braces, which always bear to each other at every point the proportion of the vertical height of the panel of the truss to the diagonal, is least at the centre, and it increases towards each end, where it attains a maximum, the strain on each end brace being equal to half the weight of the bridge and its load when uniformly loaded.

The counter-braces, when the bridge is uniformly loaded, bear no strain, and under other conditions of loading they perform a negative rather than a positive duty, since they are not capable of, nor designed for resisting tension. The duty they perform is this—when the bridge is fully loaded the counter braces are wedged up, the bridge is therefore constantly strained to the same extent as it would be under a maximum passing load, the effect of which would be instead of additionally instressing the various members to relieve them for the moment from the strain to which they are constantly subject. To provide for any deflection caused by the wedging up of the counter-braces, a camber is given to the truss, by making the lengths of the panel-tops slightly greater than the panel-bottoms.

The chords are made of two, three, or more sticks depending upon the magnitude of the span, secured together at intervals with bolts passing through distance blocks, leaving a clear space between the sticks to admit of the free circulation of air.

In the top chords bearing a compressive strain, each stick or member bears its due proportion of the strain, but in the bottom chord, which resists a tensile strain, provision must be made for splicing, so that if the chord consists of three members two only will be capable of resisting strain, and if the number of members is four then three only will resist the strain.

In the example selected, the height of the truss (20 feet), which, at a glance, as compared with the span, may appear out of proportion, has been adopted so as to enable the trusses to be laterally braced against wind pressure at a sufficient height to enable the locomotives and trains to pass underneath.

The span of the truss is 80 feet, the static or dead load is 0·6 ton, and the variable or live load 2 tons per linear foot. The strains on the truss are very simply determined, and written down in the manner shown hereunder. (Fig. 26, Plate XI.)

Calculation of Stresses.

Let n = number of panels = 8; panel length = 10 feet; span = 80 feet.

W = weight on one panel due to uniform or dead load = 6 tons.

W″ = weight on one panel due to variable or live load = 20 tons.

ab = 10 feet, Bb = 20 feet. $aB = \sqrt{ab^2 + Bb^2} = 22{\cdot}36$; $\frac{aB}{Bb} = 1{\cdot}118$.

Maximum compression on braces:—

$$aB = \left(3\tfrac{1}{2}\,W + \tfrac{28}{8}\,W''\right)\frac{aB}{Bb} = (21 + 70)\,1{\cdot}118 = \underset{\text{Tons.}}{101{\cdot}73} = \underset{\text{Lbs.}}{227{,}893}.$$

$$bC = \left(2\tfrac{1}{2}\,W + \tfrac{21}{8}\,W''\right)\frac{aB}{Bb} = (15 + 52\tfrac{1}{2})\,1{\cdot}118 = 75{\cdot}46 = 169{,}041.$$

$$cD = \left(1\tfrac{1}{2}\,W + \tfrac{15}{8}\,W''\right)\frac{aB}{Bb} = (9 + 37\tfrac{1}{2})\,1{\cdot}118 = 51{\cdot}98 = 116{,}450.$$

$$dE = \left(\tfrac{1}{2}\,W + \tfrac{10}{8}\,W''\right)\frac{aB}{Bb} = (3 + 25)\,1{\cdot}118 = 31{\cdot}30 = 70{,}120.$$

$$eD'' = \left(-\tfrac{1}{2}\,W + \tfrac{6}{8}\,W''\right)\frac{aB}{Bb} = (-3 + 15)\,1{\cdot}118 = 13{\cdot}41 = 30{,}050.$$

Maximum stresses on ties:—

$$Bb = \left(3\tfrac{1}{2}\,W + \tfrac{28}{8}\,W''\right) = (21 + 70) = 91{\cdot}00 = 203{,}840.$$

$$Cc = \left(2\tfrac{1}{2}\,W + \tfrac{21}{8}\,W''\right) = (15 + 52\tfrac{1}{2}) = 67{\cdot}50 = 151{,}200.$$

$$Dd = \left(1\tfrac{1}{2}\,W + \tfrac{15}{8}\,W''\right) = (9 + 37\tfrac{1}{2}) = 46{\cdot}50 = 104{,}160.$$

$$Ee = \left(\tfrac{1}{2}\,W + \tfrac{10}{8}\,W''\right) = (3 + 25) = 28{\cdot}00 = 62{,}720.$$

Maximum stresses on chords:—

$$ab = BC = 3\tfrac{1}{2}\,(W + W'')\,\frac{ab}{Bb} \;.\;.\;.\;.\;.\;.\;.\; = 45{\cdot}5 = 101{,}920.$$

$$bc = CD = 3\tfrac{1}{2} + 2\tfrac{1}{2}\,(W + W'')\,\frac{ab}{Bb} \;.\;.\;.\;.\;. = 78{\cdot}0 = 174{,}720.$$

$$cd = DE = 3\tfrac{1}{2} + 2\tfrac{1}{2} + 1\tfrac{1}{2}\,(W + W'')\,\frac{ab}{Bb} \;.\;. = 97{\cdot}5 = 218{,}400.$$

$$de = \;.\;.\;. \;3\tfrac{1}{2} + 2\tfrac{1}{2} + 1\tfrac{1}{2} + \tfrac{1}{2}\,(W + W'')\,\frac{ab}{Bb} = 104{\cdot}0 = 232{,}960.$$

In the top chords the strain is compression, and in the bottom chord tension.

Having thus determined the strains, it is expedient that they should be tabulated, so as to show at a glance the magnitude of the stress on each member of the truss, and the proportioning of that member to the stress it has to bear.

TABULATED STATEMENT SHOWING THE PROPORTIONING OF THE VARIOUS MEMBERS TO THE STRESSES BORNE BY THEM.

Particulars of Member Instressed.	Total Stress on Two Trusses.	Stress on One Truss.	No. of Members to Bear Stress.	Stress on each Member.	Theoretical Cross-section of each Member.	Actual Cross-section of each Member.	Dimensions of each Member.
Braces—	Lbs.	Lbs.		Lbs.	Ins.	Ins.	Ins. Ins.
a B	227,893	113,946	2	56,973	103·5	104	2 pieces 8 × 13
b C	169,041	84,520	2	42,260	77·0	80	2 ,, 8 × 10
c D	116,450	58,225	2	29,112	55·0	64	2 ,, 8 × 8
d E	70,120	35,060	2	17,530	32·0	48	2 ,, 8 × 6
Counter brace—							
e D″ inches...	30,050	15,025	1	15,025	27·0	49	1 piece 7 × 7
Tie rods—							
B *b*	203,840	101,920	2	50,960	5·09	4·90	2 bolts $2\frac{1}{2}$ dia.
C *c*	151,200	75,600	2	37,800	3·78	3·97	2 ,, $2\frac{1}{4}$,,
D *d*	104,160	52,080	2	26,040	2·60	2·76	2 ,, $1\frac{7}{8}$,,
E *e*	62,720	31,360	2	15,680	1·56	1·76	2 ,, $1\frac{1}{2}$,,
Top chords—							Ins. Ins.
B C	101,920	50,960	3	16,987	31·0	72	3 pieces 12 × 6
C D	174,720	87,360	3	29,120	53·0	72	3 ,, 12 × 6
D E	218,400	109,200	3	36,400	66·0	72	3 ,, 12 × 6
Bottom chords—							
a b	101,920	50,960	2	25,480	25·4	72	3 ,, 12 × 6
b e	174,720	87,360	2	43,680	43·6	72	3 ,, 12 × 6
c d	218,400	109,200	2	54,600	54·6	72	3 ,, 12 × 6
d e	232,960	116,480	2	58,240	58·2	72	3 ,, 12 × 6

In the above tabulated statement the limit of strains is as hereunder, viz.:—

	Lbs. per Square Inch.
Timber in compression	550
Timber in tension	1,000
Wrought iron	10,000

Strain on Floor Beams.

The distance from centre to centre of floor beams is 6 feet, and the maximum load carried on this interval is 12 tons, supported at two intermediate points, that is to say 6 tons on each rail situated 2 feet 6 inches on each side of the centre of the span, which, between supports, is 13 feet. The equivalent centre load is therefore

$$\frac{6 \text{ tons} \times 4 \text{ feet} \times 2}{6{\cdot}5 \text{ feet}} = 7{\cdot}38 \text{ (say } 7\tfrac{1}{2} \text{ tons).}$$

A fir or Memel beam, 13 feet between supports, to carry a safe load of $7\frac{1}{2}$ tons concentrated at the centre or a breaking weight of 75 tons or 168,000 lbs., should be of the following dimensions. Assuming the floor beams to be in two flitches bolted together, each flitch 9 inches wide, or the two together 18 inches wide.

Then the depth or

$$D^2 = \frac{168{,}000 \text{ lbs.} \times 13 \text{ feet}}{545 \times 18 \text{ inches}} = 222, \quad D = 14{\cdot}89 \text{ inches (say 15 inches).}$$

The depth is thus 15 inches.

Track Stringers.

The greatest length of span unsupported between the floor-beams is 4·25 feet, and the maximum distributed load is 8·5 tons, which would be equivalent to a concentrated load of 4·25 tons, or 2·125 tons or 4,760 lbs. on each stringer.

The dimensions of a square beam, to carry a safe load of 4,760 lbs., or a breaking weight of 47,600 lbs., should be :—

$$\sqrt[3]{\frac{47600 \times 4{\cdot}25}{545}} = \sqrt[3]{371} = 7{\cdot}186 \text{ inches.}$$

The dimensions actually adopted are 9 inches.

Graphic Solution of Stresses.

The strains on the main truss can be very simply solved without the aid of any of the foregoing calculations, by graphic statics, in the following manner :—First construct a diagram of the truss to any scale, as shown in Fig. 26, then draw the line $a' a''$ in Fig. 27 parallel and equal to $a' a''$ in Fig. 26 (Plate XI.). From the centre X of the line $a a''$ in Fig. 27 let fall the perpendicular X Y, making it equal to $\frac{W L}{8 D}$. Here W = the total weight of bridge and load, L the length of span, and D the depth of truss from centre to centre of chords. On the line $a' a''$, construct the parabolic curve $a\ y^3\ y^2\ y^1$ Y, etc., having its vertex at Y, then the abscissæ $x^3\ y^3$, $x^2\ y^2$, $x^1\ y^1$, X Y drawn in line coinciding with and prolonging the vertical lines Bb, Cc, Dd, and Ee in Fig. 26 will give the maximum strains in the chords.

To determine the strains in the web-members, from the point a'' lay off at right angles to the line $a'' a$ the line a'' M, making the distance a'' M equal to the reaction at each abutment of the static load which equals one-half of the weight of the bridge, then join X M. Then the ordinates from the line $a'' a$ to the line X M will represent at the various *loci* the magnitude of the strains due to the static or dead load.

Similarly, lay off from a'' in an opposite direction, the perpendicular a'' N, making a'' N equal to the reaction of the live or variable load, which would be one-half of the total live load. Then construct the parabolic curve N $o\ o^1\ o^2\ o^3\ o^4\ o^5\ o^6\ o^7$, etc., having its vertex above its base = a'' N. The complement of each ordinate drawn from o, o^1, o^2, o^3, o^4, o^5, o^6, o^7, etc., to the line $a\ a''$ will represent by scale the stresses on the vertical web-members Bb, Cc, Dd, Ee, etc., and the stresses on the braces will be in the proportion of the diagonal to the perpendicular, as shown in the left side of the diagram.

It may be observed that in graphic statics the larger the scale adopted for the diagrams the more closely can the stresses be evaluated.

The approximate quantities of materials in this bridge are as under :—

	£	s.	d.
1,898 cubic feet of timber, at 3s.	284	14	0
86 cwts. of bolts, nuts, etc., at 12s.	51	12	0
55 cwts. of cast iron in angle-blocks separators, etc., at 6s.	16	10	0
Total cost of bridge	£352	16	0
Cost per foot run, span being 80 feet ...	£4	8	2

Conclusions.

The conclusions to be derived, briefly stated, are, that for short spans up to 20 feet, where the height of the viaduct is not great, a bridge of the type illustrated in example No. 1 is the most suitable and economical, and for spans from 20 to 40 feet, with a moderate height, that illustrated in example No. 2 is a very good type of bridge. For viaducts of any considerable height it would be very difficult to design a better arrangement than that introduced by Mr. Carl Pihl, and illustrated in example No. 3. For bridges of spans ranging from 40 to 150 feet the Howe truss is beyond doubt the most efficient, simple and economical truss that can be adopted.

Mr. Edwin Gilpin, Jun.'s paper on "Explosions in Nova Scotian Coal-mines" was taken as read.

EXPLOSIONS IN NOVA SCOTIAN COAL-MINES.

By EDWIN GILPIN, Jun., A.M., F.G.S., F.R.S.C., etc., Deputy Commissioner and Inspector of Mines.

At present coal-mining is carried on in Nova Scotia in three widely separated districts. The geological horizon however of all is the same, the middle or productive division of the Carboniferous.

The coals from these districts vary somewhat in their general character. The Cape Breton seams are enclosed in strata holding many beds of sandstone with shales, arenaceous and argillaceous, presumably in large part formed from the re-worked beds of the adjoining Millstone Grit. The measures are usually presented at easy angles, and free from faults. In Pictou county the beds are thick, heavily inclined, frequently faulted, and at points associated with a great thickness of shale, carbonaceous, and occasionally somewhat bituminous. In a part of the Pictou district, to be more specially referred to later on, these shales attain a thickness of about 500 feet.

In the Cumberland district the natural sections of the Joggins present long-continued alternating deposition of shale and sandstone, with strata dipping at moderate angles, and not notably faulted. At Springhill, some 18 miles away, the same measures assume high angles, and are disturbed by heavy faults.

Broadly speaking, the Cape Breton coals are the most bituminous, followed by the Cumberland, and then by the Pictou coals. The coals of the two latter districts are rather of the free-burning type, although in some cases coking, but not as in the case of the Cape Breton coals almost invariably coking and adapted for gas-making.

The following average of analyses from a paper by the writer on Canadian coals will serve to show the differences in a general way :—

	Cape Breton.	Pictou.	Cumberland.
Moisture	0·75	1·19	1·46
Volatile combustible matter	37·26	29·10	33·69
Fixed carbon	58·74	60·63	59·35
Ash	3·25	9·34	5·50

The generally higher percentages of ash in the Pictou and Cumberland coals may be connected with the presence of the included beds of shale

already referred to, as compared with the small ash percentages of the Cape Breton coals associated with a larger proportion of sandstone-beds. The lesser thickness of the Cape Breton Coal-measures and the more bituminous nature of the coals may be contrasted with the free-burning characteristics of the western coals included in measures of much greater thickness.

The official records of coal-mining in Cape Breton go back to the year 1785. From that date to this the annual production has been comparatively small, amounting for the year 1893 in round numbers to 1,000,000 tons of coal. During this long period the deepest shaft and workings have equalled a vertical depth of about 700 feet. Gas has seldom been met in quantities large enough to cause trouble. One accident only requires record in this connexion. The mines in this district were for many years damp along the outcrop workings, and can at this date be fairly called dusty in part of one mine only, attaining a vertical depth of about 700 feet.

The regularity of the seams, the overlying water-saturated sandstones, the thin cover, all, combined with changes of water-level effected by shafts, appear to have resulted in an almost complete discharge of gas from the seams as far as they have been worked.

There have been a number of cases of ignition of gas in Cape Breton, only one of which would be classed as an explosion, the remainder being of trifling extent due to small local collections of gas or to remissness in sweeping the workings thoroughly with the air. The explosion in question took place at the Sydney mines, on May 21st, 1878. The work of opening out the submarine operations was being pushed. From the pit-bottom an engine-plane ran to the north-east, and an engine-deep had been put down about 1,000 feet to the south-east to a landing. From this point a pair of levels had been driven southwardly for about 130 feet beyond a cross-cut which ran from the low level up through a few rooms that had been driven parallel to the levels. There was also a head between the levels within a few feet of the faces. It appears that a canvas door stood at the mouth of the upper of the two levels and forced the air-split for these deeps down the deep slant, along the low level, and then up along the working-faces. The places being idle, part of the canvas on the door was removed to another part of the pit, laying the two leve's dumb. After standing for several days, the place was entered by the upper level by the overman and a deputy carrying open lights, and a severe explosion ensued killing five men. The bodies of the over-

man and deputy were found about 60 feet from the face and not much burned. At this point the coal was not coked, nor were the props disturbed. In the lower level, however, there was evidence of great heat and violence; the explosion could be tracked out along the low level into the deep, where part continued across into the north deep workings and part towards the pit-bottom. When it is remembered that these levels from the south-east deeps were in only 130 feet beyond a cross-cut going to the rise and were connected by a head at their face, it is presumable that the management minimized the risk of gas accumulating. There was probably, judging from the position of the lamps and bodies, gas lying back to a distance of 60 feet from the face in both levels, and probably about 6,750 cubic feet of air containing gas as calculated by the manager, Mr. R. Brown. It would appear that the ignition of gas in the upper level flamed into the gas in the lower level, and, bearing dust and air with it, afforded an opportunity for the violence of the explosion. The workings are referred to by the inspector as dry, and the roadways as deep in dust. The management considered that although dry, the mine would not be considered as dry and dusty in a dangerous sense. This view would seem to be partly borne out by the fact that the coking of the coal and props did not extend for over 450 feet from the face of the low level. The management consider that, during the many years this seam has been worked, dust has played no part in any of the small explosions of gas which have occurred from time to time.

In Pictou county, the chief coal-mining interest centres around the main seam which lies at an angle of about 17 degs. and is bedded in the great mass of shales already referred to. The comparatively open character of the coal, lying in dry surroundings, and broken by numerous faults has made it a gas-drainage channel for a large area. This constant exudation of gas from the outcrop of the seam, some 40 feet in thickness, is reported to have been long known in Indian tradition, and at a distant date the ignition of the gas has caused a local fusion of a large body of shale overlying part of its outcrop. The word Pictou is stated to be the Indian equivalent for explosion, and may be connected with this fire. The gas exuding under the still water of the river crossing its outcrop could be ignited. Under these circumstances it will be seen that the operations in this seam begun in 1827 by miners accustomed to the thin seams of the North of England were attended with unusual difficulties. Little reliable information can now be secured as to the cause of the early explosions and fires in the Albion mines.

Systematic operations were commenced in 1827. On December 29th, 1832, fire was discovered in the pit, and it was found necessary to flood the workings. This fire was established to be of incendiary origin, but the guilty parties were never discovered. In 1834, the mine caught fire from a feeder ignited by a shot; in 1836, a heavy explosion killed several men; in 1838, during the sinking of No. 2 pit, an explosion killed three men. It may be remarked here that all shafts sunk in the great shale-bed overlying the main seam gave off gas.

Finally, in 1839, a feeder of gas lighted by a shot set fire to the coal and in spite of every effort the pit exploded with great violence during the night. So intense was the heat of the flames in the shaft that the hoisting-chains, etc., were melted. This first range of working was then abandoned.

Other shafts were then sunk to the dip. In 1862, night watchmen ignited gas and three men were killed. In 1867, these shafts were lost by a fire from an ignited feeder and filled with water.

In 1869, a new shaft called the Ford pit was sunk further to the dip, striking the coal at about 900 feet. As it was being holed around the shaft-pillar it caught fire and had to be flooded. This pit was re-won and successfully worked until 1880, when an explosion took place killing forty-four men, and it has remained practically closed since that date.

There is little information available about the earliest of these fires and explosions. Prior to 1869 the workings were damp, except in some of the working-places in the lowest deeps, as water followed the miners from the outcrop. The ventilation by furnaces with upcast shafts not exceeding 300 feet in depth was unable to sweep the huge chambers in this thick coal which were constantly accumulating gas. It is probable that the imperfections of the ventilation by allowing vitiated air to mix with the gas sensibly diminished its inflammability. It is stated that on one occasion the gas came off so strongly that on removing it by a heavy fall of water it fired at the boilers on the surface some 50 feet from the shaft.

The writer appends a copy of the special rules in force at these mines in the year 1840, which are of interest as showing a state of affairs in contrast to the practice of the present day and as showing that then, as now, the use of gunpowder was intimately connected with fire.

The Ford pit after a lifetime of about ten years was the scene of a violent explosion already referred to. In this case the side of the pit in which the explosion occurred had been reported as free from all but traces of gas at one or two points, up to an hour before the entry of the colliers (the testing was done with Clanny lamps, and the faces dated by the examiners).

The first explosion took place at 6 o'clock in the morning, and blew off the fan-drift cover. The rescue of bodies and the restoration of the ventilation were being successfully carried on when the presence of fire was detected, and shortly after a series of explosions rendered it necessary to close the shafts and seal the landings with water.

All attempts to account for the immediate cause of the explosion are necessarily conjectural, as all were lost who had entered the section that was the seat of the explosion, and the fire prevented a complete exploration after the first explosion. The chief points, however, that were observed by the exploring parties were that the flame of the explosion had not reached within several hundred feet of the shaft-bottom, that immense volumes of dust had been blown towards the shaft, and deposited on each side of the shaft. It appeared that the explosion had passed along a level to the dip of the wagon-road at the shaft-bottom, broken the back of the lamp-cabin, and had ignited coal-dust at the open light always kept there, killed the lamp-man, and showed traces of an explosion back to the shaft, or contrary to the direction whence the explosive wave had originally come. The shaft and approaches were all wet, and gas was unknown in its vicinity. At a distance of about 900 feet from the shaft-bottom the workings were dry and dusty. There appears to be little doubt that this explosion originated from a shot fired by the fireman shortly after the pit began to work ; that it was largely assisted by dust, that on arriving at the wet ground near the shaft bottom no signs of fire were visible on boards, canvas, etc., and that the finer particles of dust coming in contact with the open flame at the lamp-cabin about 100 feet from the shaft caused a slight secondary explosion.

The local nature of the explosion at the lamp-cabin was corroborated by the evidence of the wounded man, the position of the broken stoppings and the fact that the stables near the pit-bottom in the path of the first explosion showed no signs of flame. A short time ago the pit was pumped out and attempts made to reopen it, but outbreaks of spontaneous combustion in the old workings have led to a temporary cessation of the work.

This main seam is also worked about 3 miles to the westward by the Intercolonial Coal Co. Its character as regards gas is nearly the same as the similar workings in the Albion mines. On May 13th, 1873, a shot in one of the levels ignited a feeder.

The shot was in the bench or lower of the two slices by which the coal was mined. Owing to some want of care, the shot instead of

loosening the whole of the bench so that it could be readily removed, only broke the coal at the back of the bench next the face. Owing to the violent issue of burning gas through the mass of cracked coal it was found impossible to clear the bench away so as to get at the feeders. In a short time it was decided that the pit would have to be abandoned, but before all the men were got out a terrific explosion occurred causing the death of fifty-five persons. This explosion is believed to have been one of the most violent ever known in the history of coal-mining. After several days' work the openings were sealed. About two years later the mine was reopened, and has been working successfully since. The explosion presumably resulted from some body of gas being drawn upon the furnace fire from the rise-workings owing to a derangement of the ventilation, as several men who were in the workings near the point where the fire started escaped after the explosion. The pit was damp and not dusty.

Gas was given off very abundantly in this mine, and feeders of gas were daily ignited by the shots. In fact, no powder should have been used, but as there was at that time no Mines Regulation Act, it was impossible for the Government to enforce a prohibition in any way at variance with the practice common in other mines less gaseous. At present the improved mechanical ventilation, the use of safety-lamps and roburite have proved so far an effective safeguard, and the amount of gas evolved does not seem to have increased with the depth of the workings.

The main seam is underlain by the deep seam, being separated by 150 feet of shale. The seam is about 20 feet thick. Its character at the Albion mines has been decidedly less gassy than the overlying main seam. In 1858, there was an explosion of gas in the main levels which were in faulted ground. This explosion killed two men and wounded several others, and was entirely a gas explosion as the levels were making gas, and it was very wet out to the shaft-bottom. A similar lighter explosion occurred in 1864.

At the Intercolonial colliery during the latter part of the year 1892 a tunnel, 1,000 feet long, was driven from the 3,200 feet level in the main seam to cut the underlying or deep seam. The explosive used was roburite, and no difficulties were experienced until the lower part of the face of the tunnel struck the top of the seam when heavy feeders of gas were met. Two shotholes were fired in the rock preparatory to

entering the tunnel in the seam. The shots were fired together by electricity, a sharp explosion took place followed by the ignition of the feeders. The coal took fire, and after efforts were unsuccessfully made to put out the fire, dams were built, and work soon after resumed. Such enquiry as could be made showed that the shots were properly tamped, etc. It would appear that as the shots had not a solid backing of rock, they blew out and fired gas. The shot-firer had reported the place fit to fire shots in. The commission appointed some time before by the Government of Nova Scotia to enquire into the question of explosions reported that the precautions usually adopted in regard to testing for gas when gunpowder is used should not be omitted in the case of roburite or acadia flameless explosive (a local explosive possessing a high degree of safety). In this case considering that a large amount of gas was continually being evolved it would have been more in accordance with the spirit of the report of the commission not to have used any explosive. The instructive fact remains that roburite fired under apparently normal conditions ignited gas. The manager of the mine states that this explosive has been largely used by him and has given general satisfaction. In this connexion the deputy inspector for the Pictou district reports in the same year that flames had been seen by a number of parties from both these explosives.

It may be mentioned that the tunnel was dry, that the strata were composed of fireclay and blue shale, and that dust played no part in the explosions. After the face was recovered the seam was cross-cut, and as the drainage of gas was very heavy it was allowed to stand pending the drivage of a place downhill from the crop workings.

This seam was the seat of a very unusual explosion on August 8th, 1893. A small mine had been in operation for some years and dip works were being extended on the pitch of the seam to meet the tunnel—already referred to as the seat of an explosion caused by roburite. Owing to unusually dry weather the supply of water for the colliery boilers grew scanty. First, the working of the mine was abandoned, and then as the supply of water grew smaller, the steam was shut off the Schiele fan, and recourse had to natural ventilation. This was of course not counted on as effective as the seam was very gassy, but no danger was feared as the mine was closed and would not be entered again until the ventilation was restored. Naturally the mine filled with gas. On the day referred to, a heavy thunderstorm passed over the pit, a discharge of lightning injured several buildings close to the pit, and ignited the gas in the mine causing a heavy explosion. The discharge had presumably struck the iron pulley-wheels,

and followed the steel rope down to the cage which was standing about 20 feet from the bottom. The flash would occur at this point, and in an atmosphere almost undoubtedly filled with explosive gas. This accident, fortunately, accompanied by no loss of life, shows conclusively the effects of lightning, the pit being closed, and no person in the vicinity, and the explosion coinciding with a heavy lightning discharge.

The third seam underlying the deep seam about 85 feet was, on January 15th, 1888, the scene of a very violent explosion.

During the summer, part of the pillars in a panel in the third seam were drawn beneath the cage pit-workings at a point where a fire had been built off about the year 1872. This fire was believed to have been extinguished, and no danger was anticipated. After several pillars had been drawn the fall ran up to the cage pit-workings, hot stythe came into the third seam, and finally some of the stone that fell was found to be sensibly warm. The panel was built off at once, a work of no great difficulty, as there were only five openings. The temperature of the interior of the panel did not increase for several weeks, and it was believed that the fire would be extinguished. One Sunday morning, smoke was found in the returns, and shortly after a very violent explosion took place which destroyed the bankhead, and reduced tubs, brattice, etc., to matchwood. The side of the pit in which the explosion occurred was built off, and no further trouble has been experienced. The immediate origin of the fire is unknown. But the presence of smoke in the return before the explosion would make it appear probable that a fall or a slight explosion broke one of the stoppings, and that the furnace in the third seam drew gas from the upper seam upon the fire. Presumably the effect of the explosion was increased by dust, although the mine would not be classed as dry and dusty.

In the eastern part of the Pictou district the McBean seam is worked by the Vale colliery. On February 18th, 1885, an explosion occurred causing the death of thirteen men. It was claimed by the management that it was caused by dust alone from a blown-out shot. After a very careful enquiry it appeared most probable that it was due to a small body of gas and extended by dust. The writer quotes the report of the deputy inspector, Mr. Maddin, in whose charge the enquiry was placed.

The seam which dips at a heavy angle was opened by a slope which had been for some time working through the 1,800 feet levels, and was being sunk for a new lift. The sinking was down about 500 feet below the 1,800 feet level. While sinking, back slopes are driven on each side of

the main slope in the following manner :—Heads are driven right and left, at intervals of about 60 feet as far as the line of the proposed back slopes. The back slopes are formed by connecting the faces of these heads by shoots or rises driven up hill from each head. It was known that these shoots when driven up off the air would gather gas. The air for the section of the mine in question entered by the main slope.

On the west side of this slope, at the 1,300 feet level, there were two check-doors which, when shut, sent the air direct to the dip, but when opened allowed most of the air to take a short cut to the fan. These doors were placed to allow the timber to be taken from the slope, and to be carried to the head of the shoots to be lowered to the working-places in the level below.

Men were engaged in this work at the time of the explosion, and it is believed that some derangement of the ventilation at this point allowed gas to accumulate in a head in the sinking, in which a miner named Foley was working about 100 feet from the face of the sinking; and that the restoration of the air-current, which was strong and sharp, forced the gas upon Foley's lamp. He was burned to a crisp, while the men nearer the face were almost untouched by fire. The timbers in the slopes from the head in which Foley worked down to the face of the sinking gave unmistakable evidence that the explosion came from above, while the timber up the slopes from Foley's head for 400 feet to the 1,800 feet level gave like evidence that the explosion came from below. At the 1,800 feet levels the check-doors were destroyed, and signs of the explosion found for about 400 feet from the slope. The stoppings all along the slope were blown out, and the slope badly wrecked, but at no point did the explosion extend over a few hundred feet to the right and left of the slope. The floor of the main slope in the sinking was damp, but there was much dust on the timbers in the slope, and the coal gave off a good deal of dust under a vertical pressure of about 1,200 feet. The explosion found the mine at the height of the winter in its driest condition. When the water which had gathered at the face of the sinking was removed a shothole was found. A very careful examination into the matter failed to produce any evidence that the hole had been charged. The explosion had followed the line of least resistance, viz., directly up the slope to the open air, and resembled one at the bottom of a shaft.

In the absence of the explanation afforded by the fact that on previous occasions the accidental neglect in shutting the doors on the 1,300 feet level had caused an accumulation of gas in the sinking, and by the fact that at the time of the explosion the doors in question were more or less open, it might have been reasonably urged that it was a dust explosion.

On February 21st, 1891, an explosion accompanied by heavy loss of life took place at the Springhill mines, Cumberland county. At this point three seams are worked by three slopes : all the workings had been connected by tunnels, but those leading into the north seam had fortunately been built off before the explosion. The seams dip at an angle of about 27 degs., and are opened by slopes, with levels at convenient distances apart. From the levels places are driven to the rise on the full pitch of the seam, and horizontal bords turned away. The tubs are raised and lowered, between the bord-mouths and the level, on platforms worked by counterbalances.

The seat of the explosion was in the No. 6 and No. 7 balances of the 1,900 feet west level of the east slope, at the face of the working of this section. These balances, about 600 feet in length, extend on the full pitch of the seam from the 1,900 to the 1,300 feet levels, and take the coal from the usual horizontal bords or working-places.

These balances were connected with the 1,300 or stony-level, and were ventilated by air from the lower level, which was divided between the balances and uniting at the 1,300 feet level ventilated the workings above that level, and passed to its outlet beyond the faces of the workings above the 800 feet level. The air was provided by a downcast fan, and appeared to be ample for the extent of workings. Repeated examinations appeared to indicate that the explosion started from a point about the centre of No. 7 balance (the furthest in balance) and to have gone up and down the balance, wrecking the working-places branching off from it. Also to have penetrated into No. 6 balance through the lower working-places in it, which had been worked through into No. 7 balance, and in a similar manner to have wrecked that and the working-places branching off from it. As the connexions between the top of the balance and the 1,300 feet level were comparatively small, the force of the explosion extended but a few feet through them into that level. The openings into the 1,900 feet level being larger, the explosion was felt severely at the foot of the balances, and the two levels were wrecked into their faces a distance of about 400 feet, and towards the slope for a distance of about 1,500 feet. The force of the explosion was slightly felt at the bottom of the slope, and did not attract attention at the surface, except by a momentary agitation of the fan at the east slope and a slight puff of air at the west slope in the underlying seam, which was connected by a tunnel with the east slope seam, a few feet from the top of the No. 6 and 7 balances. The explosion ignited some canvas-brattice and boards in No. 6 balance, but this fire was extinguished without difficulty.

The workings of the No. 7 balance were naturally very dusty, and were systematically watered, an ample supply of water being led through them by pipes from a large pump standage or lodgment on the upper level. The water that made on the 1,300 feet level was used for watering No. 6 and 7 balances. The watering was effected by putting a valve on the pipe in each working-place in No. 7 balance, so that a coal-box, holding a barrel, could be run under it and filled, and the orders were that it should be thrown on the roof and sides of the working-places. Water was also allowed to run into the bords, and the shot-firers were instructed to see that the vicinity of the shot to be fired was damp. The amount of water available, and the directions for its use, should, in the writer's opinion, have kept the stationary dust well damped.

The reports show that the workings in No. 7 balance were free from gas on the morning of the explosion, and the available evidence points to the fact that there was no lying gas up to the time of the explosion, as the brattice-men who had completed their special work in other parts of the slope were killed by the explosion in the lowest bord of the balance on their regular rounds for the purpose of testing stoppings, brattice, etc. Evidence was given to show that the levels had been making gas for some time, but the ventilation was good, and no accumulations were permitted.

From the evidence produced, the directions to the shot-firers, night-men, brattice-men, etc., were adequate, and properly carried out. There appeared in some instances to have been latitude allowed by shot-firers to miners in respect to charging holes before they were examined. In the writer's opinion, when the supervision of shot-firers is considered necessary, no hole should be charged before it is measured by the shot-firer and the amount of powder used should be subject to his opinion. The writer is the more inclined to this opinion in reviewing this matter, as the evidence tended to show that the "flaming" shots referred to in the investigations were in some instances contributed to by a want of attention in placing the hole and the charges of powder.

In the No. 7 balance locked lamps were used, except by the cage-runner in the counterbalance, who was allowed to use an open light. The author does not know that this in any way contributed to the explosion, but it may be conceived that in the case of an explosion driving before it and beyond its own sphere of ignition, a mixture of dust and gas, an open light might be instrumental in starting a second explosion. It is further to be remarked that the men employed, who are furnished with locked lamps, are naturally inclined to be sceptical as to their value if they know that within a short distance open lights are permitted.

From the evidence taken it appeared that the manager, Mr. Swift, who was killed by the explosion, his assistant, the underground managers, and other officials were careful and attentive, and that daily reports and check reports were used.

In the No. 7 balance, when the bords were first started, the coal was worked to its full height, having a bench of about 4 feet, then a stone band, and above that about 3 feet of coal. After the bords were driven in a short distance, the fall coal and stone were left in and the bench only was worked. This coal was not worked with powder, but as the face advanced it was necessary to blow down from 12 to 18 inches of the stone, to make room for the tubs to get near enough to the face to permit of their being loaded with coal. The stone was blown down in the low side of the bords, over the rails, and stowed in the high side. A row of props along the middle of the bords held the rest of the stone up. There was consequently little shot-firing done in the balance workings. The stone is about 2 feet thick, a coarse sandstone, with streaks of coal sometimes 2 inches thick. It was shown in evidence that usually the holes for the shots in the stone were bored in the coal streaks and were in some cases partly in stone and partly in coal.

It was shown that on the day of the explosion a shot was to be fired in this stone in the No. 3 bord in No. 7 balance, and that Thos. Wilson, the shot-firer, left the bottom of the slope about a quarter past twelve o'clock, saying he had to go to No. 7 balance. The explosion occurred shortly before one o'clock, a time having elapsed, in the opinion of the witnesses, sufficient to have allowed him to reach this point, to have made the necessary preparations, and to have fired the shot. His body was found, with those of the men working in the bord, near the entrance to the place. The shot in the stone had been fired. This, coupled with the direction of the course of the explosion, showed with reasonable certainty that it had its origin in the bord, and that the shot fired by Wilson was the direct cause of the explosion.

The suggestion was made by Mr. Madden, the deputy inspector, who was at hand at the time of the explosion, and rendered valuable aid to the rescuing and exploring parties, that the immediate seat of the explosion was to be sought in the stone itself. After examining the bords in question with him, the writer is of opinion that his suggestion offers the readiest explanation as to the source of the catastrophe.

The bord is 14 feet wide, and the stone is carried by a row of props in the middle. These props were set by the miners as they advanced the face, to hold the stone, which was not of a specially strong character, con-

sequently, as the stone was not blown down until it became troublesome to move the tubs, there were always props along the side of the shots, and between the shots and the face. The effect of these props was to partly confine the shots to the low side of the bord.

As the stone was in layers, and had streaks of coal in it, examination showed that it was more or less fissured across the bord, and hung on the props, the natural effect of the shots being to blow in along the layers, to compress the props, and to cause the stone to bag between the props and the high side. That this effect was produced is shown by the fact that large quantities of this stone fell in the workings of No. 7 balance, the props being knocked out by the explosion although very short, and partly supported by the stone stowed in the high side. The hole that was fired in No. 3 bord, was, so far as could be estimated, from 2 feet 9 inches to 3 feet long. The end of the hole was in stone. The charge of powder appeared to have filled 18 inches of the hole. The shot threw down about three-fourths of the stone it was designed to dislodge, and left the balance split by the heel of the shot, and a prop near the back of the hole. There was a lype in the stone on the low side of the bord, which may have helped to lessen the desired effect of the shot.

The weight of evidence appeared to be that there had been an overcharge of powder.

It would appear that the expansion of the layers of the stone afforded space for the accumulation of gas, which would not be readily dislodged by the air-current, and an unusual opportunity of accumulation, owing to the fact that the pit was idle the preceding day. That the shot gave evidence of having been a more or less flaming one; that it ignited the gas lodged in the roof stone; that this combination of gas and powder flame acting on an atmosphere charged with a small percentage of gas and fine floating dust derived from the lower bords, caused an intense flame sufficient to propagate itself until it reached an intensely explosive state and self-supporting, swept the two balances and the adjacent levels.

The general opinion of the witnesses was that the shot-firer was a careful man, and there is evidence that the explosion was not like that of a body of gas. Men working in the lower seam under the seat of the explosion, and separated by a few feet of measures, stated that as usual, they heard a shot fired above them. Then after an interval of a few seconds it was followed by a series of detonations which appeared to shake the roof over their heads. The face of No. 3 bord inside the shot was found to be free from dust and sign of fire. The explosion broke

only a few coal tubs, and did not do much more than dislodge the props. Almost immediately after the explosion men were able to go straight into the faces of the levels, past No. 6 and 7 balances. Their lamps burned well, although they were themselves affected. These facts point, in the writer's opinion, rather to the comparatively slow progress of a dust-supported explosion than to the sudden clap of an ignited inflammable body of gas and air.

The evidence of Enoch Cox, who worked in No. 1 bord, on the same balance, supports this view. He testified that some time previous to the explosion a shot was fired in this stone that filled his working-place with flame, and ignited the gas in the stone, so that it required some effort to extinguish it. It is fair to state that the management declare they never heard of this, and that it was never reported to them.

The mine had been carefully examined on the previous day by the deputy inspector, and two days before a committee of the men had examined this mine and were quite satisfied with the ventilation and the precautions taken to keep the workings damp.

These notes give a brief account of the principal explosions that have occurred in our coal-mines. The writer has a personal knowledge of all the mines, and has been able to enquire personally into the facts connected with most of them. So far his experience has been that no explosion in Nova Scotia can be attributed to coal-dust alone, but a number of them have had their area and their destructiveness to life materially increased by coal-dust.

Special Rules in force in Pictou Co. fifty-four years ago (1840). Instructions.

Rule 1.—The overman, and at least one of his deputies or assistants, shall examine all the bords and other working-places every morning before the colliers go down. They shall meet the colliers and other workmen at the bottom of the shaft, and if they have found any gas or other cause of danger in any of the bords, shall caution the colliers belonging to such bords and give them such instructions as they deem necessary.

Rule 2.—Whilst the pit is at work an overman or deputy shall always be present at each face of the works, viz., one on the north and one on the south side, so that in case of an alarm of fire or any other accident the overman or deputy shall always be at hand or within call.

Rule 3.—When the day's work is finished the overman or his deputies shall remain in the mines for the purpose of going through every bord and carefully examining them after the colliers have left, so that no blower or gas may be left burning, or any fire concealed amongst the fallen coal.

Rule 4.—Every bord shall be furnished with a fire-bucket marked with the number of the bord, a coarse bag for beating out gas, and a tub or open-headed cask to contain 40 or 50 gallons of water. The fire-bucket and the bag shall be in charge of the colliers of each bord, who shall pay for or replace them if lost.

Rule 5.—Every panel, consisting of six bords, shall be furnished with a small cannon, which shall be kept at some convenient spot in the lowest board. The overman and deputies shall keep the cannon clean and dry and ready for use. They shall also keep the tubs constantly full of water in each bord.

Rule 6.—Every bord shall at all times be furnished with a safety-lamp, which shall be examined by the overman at least twice a week, and in case of any injury being done thereto, more than common wear, the cost of the lamp shall be charged to the colliers, in whose care it is placed.

Rule 7.—Any collier meeting with a cutter or fissure which yields gas, or with anything unusual in his bord, shall immediately report the same to the overman or deputy.

Rule 8.—No collier shall be allowed to put in more than one shot or blast at a time, into any bench or fall, without permission from the overman.

Rule 9.—After blasting either a fall or bench, the coal shall be turned back, so that no fire may be concealed amongst the loose coal, and before the colliers leave their bords they shall be careful that no blowers or gas are left burning.

Rule 10.—No collier shall work in any fiery bord unless there are other colliers working in the adjoining bords at the same time.

Rule 11.—The coal shall not be blasted or a naked light used on any pretence whatever in any bord or working-place in which the overman has forbidden gunpowder or naked lights to be used.

Rule 12.—Every person employed in the pits on passing through any air-door or trap-door shall always close it after him.

Rule 13.—No person shall unscrew his safety-lamp (where such are used) excepting when and where he is ordered or directed to do so by the overman or his deputy.

Rule 14.—When a blower or body of gas is fired by a shot or otherwise, which cannot be at once extinguished by the ordinary means, notice shall be sent without delay to the overman or deputy; and in the meantime the colliers from the adjoining bords shall be called in to give assistance.

Rule 15.—On the arrival of an overman or deputy at the fire, all the colliers and other persons who may be present or sent for shall act under his orders, and use every exertion to carry them into effect.

Rule 16.—The extinguishing-engine shall be kept in a proper house near the pit-top, and a bell of not less than 28 lbs. weight shall be hung upon the pit-frames at No. 1 shaft, with a rope leading to the bottom of the shaft, for the purpose of making signals from below without loss of time.

Rule 17.—The overman or deputy on his arrival at a fire shall, if he considers it necessary, cause the bell to be rung for the extinguishing-engine, and to give notice to the manager, or deputies, or other persons who may be on the surface, whose duty it is to be present, that they may immediately go down.

Rule 18.—In all cases of fire a most determined effort must be made with the extinguishing-engine; beyond this it is impossible to frame any rules that will apply generally. The manager and his assistants must then decide what further measures to adopt.

Rule 19.—The overman or the deputies who shall have gone through all the bords after the workmen have left the mine shall report personally to the manager, the general state of the works, and particularly whether the cannon, buckets, water

tubs, etc., are all in readiness for any emergency, and in case the manager shall be absent they shall enter their report in writing in a book kept in the office for that purpose.

Rule 20.—No deputy shall at any time whilst on duty in the pits, during working hours, leave his appointed station until relieved by another deputy, to whom he shall report the state of the works under his charge, together with any instructions he may have received from the overman.

Rule 21.—At all times, whether there is any apparent danger or not, the foregoing rules shall be strictly adhered to, without the slightest relaxation, their object being to protect the lives of the workmen, as well as the works themselves; and any person neglecting, or in any way evading them, shall, if the manager thinks proper, be dismissed from the service.

The PRESIDENT said that Nova Scotia appeared to have suffered severely from explosions. Some of the mines appeared to be very gassy and also to contain dangerous dust, but Mr. Gilpin did not attribute any of the explosions to coal-dust alone. Blasting with gunpowder seemed to have been the most frequent cause of ignition, and in one case feeders of gas were ignited by roburite. The report of the Royal Commission on Explosions from Coal-dust in Mines had focussed opinion on the subject, and their recommendations involved further legislation, which it was important should be based upon facts—so as to secure a maximum of safety without placing unnecessary hindrances or restrictions upon the mining industry. The experiments of the Explosives Committee of the North of England Institute of Mining and Mechanical Engineers were likely to throw much light on the relative safety of the various new explosives. The first report of this committee was now in the press and would shortly be published in a form obtainable by all members of The Federated Institution of Mining Engineers. The explosion attributed by Mr. Gilpin to roburite appeared to have been caused by the ignition of gas when a seam of coal was cut into by a stone-drift. This was a very interesting explosion if it were clearly established, as it appeared to be by the account, that it was actually due to roburite fired by electric fuze.

Mr. H. BIGG-WITHER wrote that the circumstance mentioned in Mr. Gilpin's paper was reported to him, and, as far as he could recollect, he was informed that the shots were fired in very broken strata which was full of gas. The conclusion he came to at the time was that the shots were placed in holes where there was actually gas, so that to all intents and purposes they were untamped shots. He might mention that the roburite used was manufactured in Canada from ingredients supplied by the Roburite Company.

Mr. E. Gilpin, Jun., wrote that in Nova Scotia they had not yet grappled directly with the dust problem, preferring at present to seek safety in exclusion, as far as possible, of explosives. All the dusty mines are gassy, and in most no explosives are used. Roburite was undoubtedly the cause of the explosion referred to as occurring when a coal-seam was cut by a stone-drift. A full account of this explosion and subsequent extinguishment of the fire has been written by Mr. C. Fergie, the manager of the colliery.* The writer encloses a copy of the Mining Regulations of Nova Scotia bearing on the use of explosives:

(8.) Any explosive shall only be used in the mine underground as follows:—

(*a.*) It shall not be stored in the mine.

(*b.*) It shall not be taken into the mine, except in a case or canister containing not more than six pounds.

(*c.*) A workman shall not have in use at one time in any one place more than one of any such cases or canisters.

(*d.*) It shall not be taken into or be in the possession of any person in any mine or district of a mine, and shall not be used except in accordance with the following regulations, during two months after any inflammable gas in quantity sufficient to show in a safety-lamp has been found in three consecutive days in any such mine; namely:—

(1.) Either in those cases of stone-work or sinking of shafts in which the ventilation is so managed that the return air from the place where the explosive is used passes into the main return air-course without passing any place in actual course of working; or

(2.) When the persons ordinarily employed in the mine are out of the mine or out of the part of the mine where it is used.

(3.) Where a mine is divided into separate districts in such manner that each district has an independent intake and return air-way from the main air-course, and the main return air-course, the provisions of this rule with respect to explosives shall apply to each such district in like manner as if it were a separate mine.

(*e.*) A competent person or persons shall be employed for the purpose of firing all shots during three months after any inflammable gas has been found in any such mine or district of a mine, or under the provisions of sub-section (*d*). He shall, before firing any shot, carefully examine the place where it is to be fired and the places adjoining. A shot shall not be fired after the first of January, 1892, except by or under the direction of a competent person appointed for the purpose and holding an underground manager's, overman's, or shot-firer's certificate.

Provided, however, if at any time the inspector of mines, together with any persons experienced in the composition or use of explosives, who he may associate with himself for the purpose, shall report that any explosive is free from danger, the Lieutenant-Governor may, by Order in Council, determine that the restrictions of sub-section (*d*) of this section shall not apply to such explosive, and in such cases such explosive may be used so long as said Order in Council remains in force.

The Commissioner may, upon representation made to him in writing by the owner, agent, or manager of any mine, that the finding of inflammable gas in three

* *Transactions of the Nova Scotia Mining Society*, vol. i., part 4, page 44.

consecutive days, alluded to in this rule, in any such mine is exceptional, and that the mine is damp, and not dry and dusty, cause an examination to be made of such mine by the inspector, and may order that the use of any explosive is obligatory under this rule only if inflammable gas is found in two consecutive days on any two consecutive weeks.

Up to the present time these special rules have been found to lead to increased attention to ventilation, etc.

The PRESIDENT then said that he had pleasure in moving a vote of thanks to Mr. Gilpin for his interesting paper.

The vote was unanimously agreed to.

The following paper by Mr. Joseph R. Wilson on "The Shaw Gas-tester for Detecting the Presence and Percentage of Fire-damp and Choke-damp in Coal-mines," etc., was then read :—

THE SHAW GAS-TESTER FOR DETECTING THE PRESENCE AND PERCENTAGE OF FIRE-DAMP AND CHOKE-DAMP IN COAL-MINES, ETC.

By JOSEPH R. WILSON, of Philadelphia, U.S.A., Member of the American Institute of Mining Engineers, etc.

During the last seventy years numerous experiments have been made in devices for the detection of the presence and percentage of explosive gas in coal-mines, commencing with the Davy lamp, which in principle and construction sufficiently resembles the safety-lamps of to-day to be correctly regarded as the prototype, whose individuality is distinctly impressed upon all subsequent inventions of this character, the distinctly fundamental principle, which so far as safety-lamps are concerned has never been departed from.

The ability of the Shaw instrument covers such a large field that it will be in order to state first what it will do, followed by its construction, and ending with its operation. Four years of careful study and daily use of the appliance enables the writer to treat the subject from each standpoint.

The first question that one would naturally ask is, what is the Shaw gas-tester? The answer, though lengthy, would be as follows:—

It is a mechanical device that can be used by the unskilled for the rapid estimation of the amount of fire-damp and choke-damp in the air of coal-mines. The results obtained being absolutely accurate to the 0·001 part.

The writer will now describe the device as shown in Fig. 1. To be brief, the apparatus is made of brass and iron, is about 2 feet square, and weighs 90 lbs. It consists of a pair of pumps A and B; one (A) takes in air, the other (B) takes in pure gas as a base to measure from. The air-cylinder is stationary, and the stroke of the piston is always constant. The gas-cylinder (B) is movable, and can be set between two graduated bars so that it will pump 1, 2, 3, 5, or any desired percentage of gas in conjunction with air from the air-cylinder, the sum of the two

always equalling 100 parts, so that if 2 per cent. of gas is taken in the gas-cylinder, 98 per cent. of air would be taken in the air-cylinder ; and if 20 per cent of gas, there would be 80 per cent. of air and so on, the calculation on the graduated beam on which the gas-cylinder operates having been made in a curve, so that the sum of the two cylinders shall always equal 100 parts, instead of 100 of air and 2 of gas, or 100 of air and 10 of gas, the product is 98 per cent. of air and 2 of gas, and 90 of air and 10 of gas. The pistons are operated by a hand-crank (N) acting on the graduated arm or lever that regulates the stroke of the piston in the gas-cylinder, and the product of the two cylinders is pumped through an ejector or mixer (not shown) into an igniting chamber (Z), which has an aperture on one side in front of a gas-jet. Should the mixture pumped into the chamber be inflammable, ignition will take place, and the expansion caused by the heat will propel a loose piston-head, held in place by a bowstring, at the end of the chamber against a gong, producing an audible sound. The addition or subtraction of 0·1 per cent. will cause this gong to ring or remain silent; in other words, this apparatus will determine the igniting-line of gases which lies within the narrow limits of the 0·001 part, and which is as fine as the line between oil and water in a test-tube. The test for inflammable gas is made on this basis, the igniting-line. Philadelphia illuminating gas rings the gong at 8·1 per cent of gas and 91·9 of air, though this will vary in the manufacture ; 8 per cent. of this gas will not ring the gong, the addition of 0·1 per cent. being necessary. This is what is called finding the standard, or base-line to measure from, which varies with the kind of gas used. Natural gas will give a standard from 4 to 6 per cent., while manufactured gas may be anywhere from 7 to 9 per cent. This difference does not alter the condition of test, as the igniting-line can be ascertained, whether it be at 4 or 9 per cent.

The air in the mines to be tested is captured by means of a diaphragm hand-pump and a 6 gallons rubber bag. The diaphragm pump is light and easily handled. The vibration of the diaphragm throws about 1 pint of air each stroke. The air is drawn in a tube $\frac{1}{2}$ inch in diameter, and forced into the bag. When filled the bag is held by the hand, in close contact with the neck, and pulled off the pump, and an ordinary paraffined cork inserted to retain the captured air. When the bags are filled small paper tags are attached to note the time of day and place where the air was captured, and the bags brought either outside or to the foot of the intake, where they are attached to the instrument, and the contents made known as follows :—

To test for fire-damp, a bag of pure carburetted hydrogen, captured

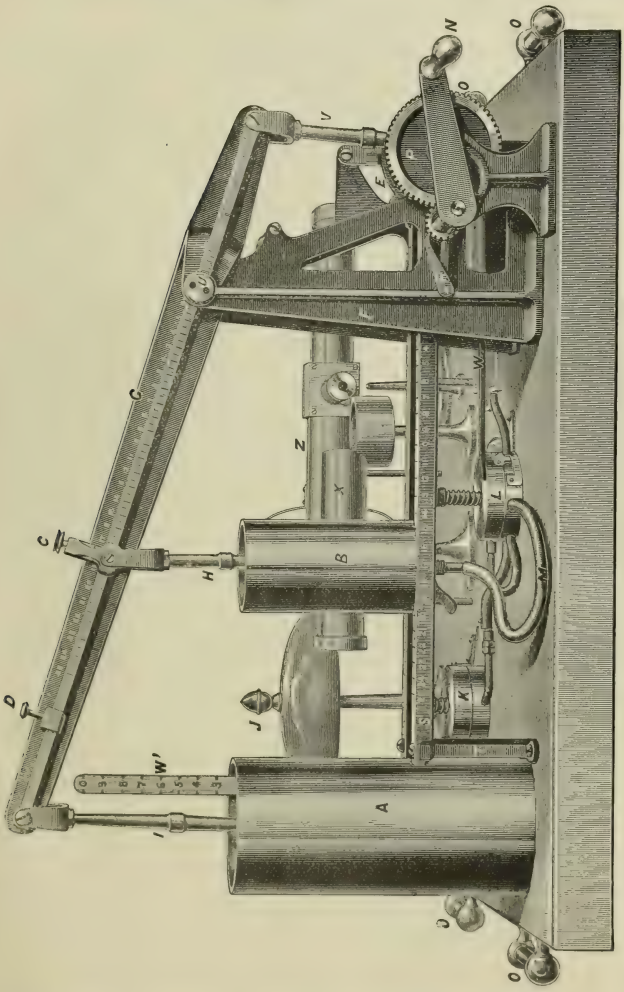

Fig. 1.

from a blower in the mine, is used as a standard, or in its absence ordinary

illuminating gas may be used. For instance, 6 per cent. of the gas will ignite, 5·9 per cent. will not, 6 per cent. is then the standard line to measure from. The process of testing a bag of gas captured in the mine is very simple. Attach it to the air-cylinder of the instrument, then pump a stroke of the air from the mine, and 6 per cent. of carburetted hydrogen into the igniting chamber. If there be any fire-damp in the air from the mine, it will manifest itself at once by producing a louder detonation than that caused by the 6 per cent. of fire-damp alone or if there is a high percentage in the bag there will not be any detonation, simply a long blue flame.

It is known that there must be 6 per cent. of pure marsh gas to ring the gong by a previous determination; so if the gas-cylinder be retreated and only 4 per cent. of fire-damp be taken and the gong still rings, the extra 2 per cent. to make the gong ring must be obtained from the bag of air captured in the mine. So keep retreating the gas-cylinder until the gong will just cease to ring; the difference between the standard 6 per cent. and the point where the gas-cylinder stands at on the graduated beam will be the contents of the bag being tested, or if the gas-cylinder is at 1 per cent. it would be evident that 1 from 6 would leave 5, and that 5 per cent. would be the contents of the bag being tested. If the gas-cylinder is at 5·8 when the gong ceases to ring, 0·2 per cent. would be the contents of the bag. A 6 gallons rubber bag of fire-damp or illuminating gas, whichever is used, will last a week, testing every day.

The valuable features of a test of this character are absolute accuracy; ability to test low percentages or any percentage; and safety in making tests, for the air can be captured in the dark by means of the diaphragm hand-pump and tested in the open air far removed from the seat of danger. Air can be captured in the goaf and disused workings, and the condition of the goaf and disused workings unmasked without any danger to the miners. With the Shaw gas-tester the manager of a coal-mine is able to determine at once the condition of the gases inflammable and non-inflammable, in every air-return, to the 0·001 part, and with the knowledge of the true condition of the gases in every section of his mine, forewarned of any danger, he will be able to take proper precautions for safety. Heretofore the mine manager in the States has had to rely on the safety-lamp for the detection of inflammable gas in the different air-currents, and unless there was $2\frac{1}{2}$ per cent. present, he would report "no gas," because the lamp failed to indicate the presence of gas if below this percentage. This is where all the danger lies. Supposing an air-return of 100,000 cubic feet per minute were to carry 2 per cent. of

inflammable gas, the ordinary safety-lamp would not give any evidence whatever of the presence of the gas, and the men would work in a false security based on the lamp-test, whereas actually there would be 2,000 cubic feet of gas per minute passing a given point, or enough to saturate 20,000 feet of air to the explosive point.

So long as the ventilation was kept up, and none of the doors were left open everything would be all right, and it would be impossible to ignite 2 per cent. of fire-damp; but on the other hand, if anything happened to the fan, or a door was accidentally left open, the 2 per cent. of gas travelling in the air-course would form in ten minutes 200,000 cubic feet of explosive compound. The man at the face feels the air grow hot and sultry, and realizes that the ventilation has been stopped or cut off and comes down with his light (frequently a naked light) to ascertain the reason. Ignorant of the true conditions, falsely imagining that there is no gas present, he walks into the explosive mixture with his light, an explosion follows and he, and perhaps a score of his comrades, are hurled to their death.

The detection not only of its presence, but of 0·1 per cent. of gas is not only a great achievement, but an absolute triumph over the old method of analysis, and may be termed the first mechanical analysis of gas ever made in the world. The writer could recount many tests, but having shown the great accuracy of the instrument for testing for inflammable gases, he will now go on a little further and show that its uses do not end with the testing of inflammable gases.

The instrument can be used for testing the sensitiveness of every kind of safety-lamp for coal-mines, and the manner in which it is done is as follows:—Attach a large bell jar to the instrument by means of a rubber tube, immerse the bell jar in a tank of water and displace the air in it, and place the gas cylinder at 5 per cent., pump a mixture of 5 per cent. of inflammable gas and 95 per cent. of air into the bell jar, displacing the water in the same by the inflowing current, place a lighted safety-lamp under the bell jar and immerse it in atmospheres containing 5 per cent. of inflammable gas, 6 per cent., 7 per cent., 8 per cent., or any per centage desired, which can be pumped upon the lamp, and the action of the flame witnessed through the glass. The elongation of the flame is not so noticeable in daylight as it would be in darkness, which latter is absolutely necessary for the accurate testing of the sensitiveness of safety-lamps by this method.

The next test is that for carbonic acid gas, and in order to illustrate this test, let us presume that the writer has exhaled his breath into one of

the rubber bags. Now the question is, how much carbonic gas does it contain? In order to ascertain this, the gas cylinder is placed at zero and the bag containing the author's exhalations is attached to the air cylinder only; by means of the instrument, the author passes the exhalations through a test-tube containing an ounce of lime-water until he produces a certain turbidity equal to an artificial standard of a known value. For instance, the artificial standard which the author uses represents 0·50 of a cylinder of 1 per cent. of carbonic acid gas and 99 per cent. of air. What volume of the exhalations will give the same result is determined by connecting a spray tube with the instrument by means of a rubber tube, and passing the exhalations from the bag through an ounce test-tube of lime-water, allowing the bubbles to pass up from the bottom of the test-tube and permeate in little globules through the water until the same turbidity as the standard is produced. The graduated strip on the side of air-cylinder shows that it has just taken 0·18 of a cylinder of exhalation to produce the same turbidity as 0·50 of a cylinder of 1 per cent. of carbonic acid gas and 99 of air. What does this indicate? Divide the 0·18 into 0·50 and we have 2·78 per cent. of carbonic acid gas in the exhalations just tested.

The last important feature of this instrument is its ability to demonstrate the effect of noxious gases upon animal life. The animal under treatment is placed in a bell-shaped glass cylinder 16 inches high, 4 inches diameter at the neck, and 8 inches at the base. The cylinder is placed horizontally on the table, with the neck towards the operator, and is connected with the instrument at the neck by means of a rubber tube. The animal rests on all fours, facing the operator, with its nose near the aperture through which the gases enter to the cylinder from the instrument or mixer.

The end of the bell-shaped glass cylinder is entirely open to the air, so that the mixture of gas and air is discharged and replaced every four seconds by each stroke of the pump, always maintaining a constant mixture, preventing stratification, or contamination through the exhalations of the subject. The cylinder being of glass and perfectly transparent enables the operator to observe every change in the condition of the animal.

The author found in recent experiments that he made in his laboratory that, notwithstanding the deadly claims made for carbonic acid gas, a rabbit existed with very little evidence of dissolution in an atmosphere of 25 per cent. of carbonic acid gas and 75 per cent. of air. This one fact alone is of great importance to the miner in case of an explosion followed by after-damp, for though 50 per cent. of carbonic acid gas will

overcome him very quickly, he could at least stand 25 per cent. for several minutes, or probably long enough to drag out a dying comrade, that is, in the absence of white damp or carbonic oxide gas.

Prof. P. P. Bedson (Newcastle-upon-Tyne) wrote that he had read with great interest the description of the Shaw gas-tester for detecting and estimating fire-damp. The method of estimation, based upon the determination of the amount of fire-damp required to be added to a given sample of gas to make an explosion of given effect, was certainly original. The mechanical appliances by which this was rendered possible displayed great ingenuity. The only point upon which he had any misgivings—which would possibly be removed by an actual examination of the apparatus—was the possibility of distinguishing to the nicety claimed by the author between explosive mixtures exhibiting such slight variations in composition as those cited.

Mr. James Ashworth (Derby) wrote that the Shaw apparatus appeared to him to be cumbersome, unwieldy, and totally unsuitable for the requirements of coal-mines. As a mechanical device it undoubtedly did not follow in the beaten track of the Davy and Stephenson safety-lamps. It, however, had one point in common with these and all other safety-lamps, viz., that the test for gas was made with "fire." Thus compared, it stood at a great practical disadvantage, and this disadvantage was increased by its very high prime cost, and because its deductions were liable to most serious inaccuracies in practical use. He did not dispute the possibility of finding the correct percentage of fire-damp, or carbon monoxide, or carbon dioxide, or sulphuretted hydrogen, if each is present by itself and mixed with air, but if there were such an ordinary mixture as fire-damp, carbonic oxide, and carbonic acid gases with air, together with others from gob-fire, it appeared to him that the apparatus could not possibly give a correct result. It was therefore essential that the composition of the gaseous mixture should be known before a really practical use of the machine could be made. Mr. Wilson was undoubtedly right in stating that heretofore the mine manager in the United States of America had had to rely on the safety-lamp for the determination of inflammable gas, and that unless there were $2\frac{1}{2}$ or more per cent. present he would report "no gas," and it was much the same in this country, where the majority of the safety-lamps used by deputies and firemen and other officials would not indicate a percentage less than $2\frac{1}{2}$. The danger arising from this cause

had been increased by the compulsory bonneting of the Davy safety-lamp—a lamp Mr. Wilson singled out as being the most sensitive for the detection of fire-damp, excepting only the alcohol or hydrogen lamp.

The PRESIDENT said the Shaw apparatus certainly appeared to be an ingenious application of mechanical methods to the analysis of gas; he thought no satisfactory opinion as to its practical use could be arrived at until it had been actually tested. Although it seemed to have been somewhat widely used in America, it was doubtful whether it was of such great value as to warrant its introduction into Great Britain, as the Pieler and other forms of alcohol gas-testing lamps, and the hydrogen gas-tester, would show as little as $\frac{1}{4}$ per cent.

Mr. J. L. HEDLEY (H.M. Inspector of Mines) said that he did not desire to detract at all from the value of the Shaw apparatus as a gas-detector, but the important point—to be considered in relation to an apparatus of this kind—was its practicable applicability for use in mines, in which the conditions varied from day to day, from hour to hour, and even from one minute to another. This apparatus, he understood, had been adopted as the official standard by the legislatures of the States of Ohio and Pennsylvania. He would like to know what was done when certain percentages of gas were detected, and whether any extra precautions were taken when the percentage of gas exceeded a given amount. It appeared to him that even if they could get a normal state of affairs throughout the pit the whole day long there should be some governing regulations, even if these instruments were used, fixing the percentages of gas beyond which the miner should not be allowed to work. He thought that this apparatus could only be used by certain persons and at certain times, and it always seemed to him that in introducing such appliances unless proper precautions were taken they incurred the additional risk of diminishing the care taken by the officials in their examinations, by the ordinary means, of the working-places for gas. This instrument could not be taken into every working-place (it was too heavy), and he very much feared that if used alone and for the reasons already stated, they would be adding to the risks that they already ran rather than reducing them. He, for one, would be sorry to see the present mode of testing for gas with a safety-lamp superseded by the Shaw gas-tester, although he would welcome the latter as supplementary to the former.

Mr. A. L. STEAVENSON (Durham) suggested that each of H.M. Inspectors of Mines should be provided with a Shaw gas-tester, and that they should visit each mine periodically and take samples of the air in the main return airways. The fact that the instrument cost £100 should not

stop the use of the machine if it were really useful. Many colliery owners had spent thousands of pounds on new ventilating fans, and the cost should not prevent the adoption of any measure of safety. The question, however, was as to whether it was really a useful machine ; it might be possible to examine air in one place and find no gas, yet within 8 feet gas might be found in abundance. The machine consequently could only be useful for testing for gas in the return airways, and would be of no use in the testing the edges of a goaf for gas, where such accuracy as 0·10 per cent. was not required or desired. It was not the practice in Great Britain, although it might be American practice, for a miner, finding himself warm, to go with a naked light in his hand to see whether the ventilation had been cut off, as had been pictured by the writer. There were several machines already in use for gas-testing which would record as little as ¼ per cent. of gas. The Liveing machine had been proved very satisfactory in practice ; it did not weigh more than 6 pounds, while the Shaw gas-tester weighed 90 pounds.

Mr. H. G. Graves (London) said that the machine had been tested by Mr. H. Le Chatelier, who gave an account of his experiments in the *Annales des Mines*.* He found that the results were practically accurate within a small percentage, but he condemned its use, as owing to its being so cumbrous, it could only be used on the surface. Mr. Le Chatelier had designed a small test-tube arrangement to be used in its place, the details of the use of which had been described by Mr. L. Poussigue in the *Bulletin de la Société de l'Industrie Minérale*.†

Mr. J. L. Hedley remarked that the gathering of a sample of the air of a mine in a test-tube would only show the state of the mine at the particular moment, and could not be taken as a standard of the condition of the atmosphere of the mine for a length of time, or for any part of the mine, other than that particular point from which the sample was taken.

Mr. M. Walton Brown (Newcastle-upon-Tyne) said that the use of such appliances as the Shaw gas-tester necessitated the use of apparatus for obtaining average samples of the air of the mine over periods which could be varied as desired. A simple form of apparatus for such a purpose would consist of a closed vessel fitted with two taps: the apparatus being filled with water and the upper tap opened, the lower tap can then be opened so as to allow of the escape of the water in any required time, and the vessel will be filled with an average sample of the air of the mine. This average sample, however, would by no means represent the most dangerous atmosphere prevailing at that point of the mine.

* Series 8, vol. xix., page 388. † Series 3, vol. vi., page 249.

Mr. A. L. Steavenson said there did not appear to be any certainty that the results recorded by the Shaw gas-tester were really accurate. They were obtained by a mechanical apparatus, and it was quite possible that the results were not correct.

Prof. F. Clowes wrote that the matter treated of was of the greatest interest to the writer, and he had occasion twelve months ago to correspond with Mr. Shaw, and to carefully study and consider his gas-tester, in order to form as satisfactory an opinion upon its suitability and merits as was possible without actually handling the instrument. Practical men who had taken part in the discussion had fully appreciated and referred to most of the important points. He considered that if the Shaw apparatus were the only accurate and delicate gas-tester it would be rash to discard it on the score of its cost and cumbrousness, and because the samples of air had to be collected, stored, and brought to the surface to be tested. But there existed at present cheap and easily portable forms of apparatus, some at least of which were equal in accuracy and delicacy to the Shaw tester. They presented the great advantage of being able to be carried into the pit, and they gave at once rapid tests for gas in *situ* down to the limit of 0·1 per cent.; they avoided therefore the very unsatisfactory process of collecting and transporting samples of the mine air to the surface. The inconvenience and delay occasioned by this collection and transport of gas samples, the fact that when collected they represented only one particular spot at one particular time, and that they were liable to undergo change in composition before they were tested, were all strong reasons for giving preference to a portable tester. These forms of portable apparatus further avoided the necessity of keeping a supply of pure marsh gas, which is a requisite of the Shaw tester, since in the delicate testing referred to by the writer of the paper the use of coal-gas of variable composition is inadmissible. Most of the forms of improved testing apparatus which are, with good reason, in favour at present are flame-tests, applied in suitable safety-lamps. The flame-test has the great advantage that it is the test commonly in use; it can therefore be at once taken up by any official who has made ordinary tests with the safety-lamp. The apparatus required is simple, non-fragile, and yields its results at once without lengthy experiment, calculation or correction. A brief description and criticism of the different gas-testing safety-lamps by the writer will be found in the report of the Cantor lectures given before the Society of Arts at the beginning of the current year. The writer has confined his criticism to the application of the Shaw tester to gas-testing in the coal-mine, and to the examination of

other forms of gas-testing apparatus. There seems to be no doubt that when applied to other purposes requiring a current of mixed gases of known composition, the Shaw apparatus will prove of the greatest service, and as an ingeniously contrived mechanical apparatus it cannot fail to excite admiration.

Mr. W. S. Gresley (Erie, Pennsylvania) wrote that he had had no experience with the Shaw gas-tester, but a few years ago he elicited the opinions of some of the Pennsylvanian state mine inspectors as to its use. These gentlemen were of opinion that, provided the whole of the apparatus was in perfect working order, by proper manipulation it could be made to indicate with sufficient accuracy that which its inventor claims for it. But as to whether the machine would ever be of any practical use in preventing gas-explosions in mines, and thereby become any real safeguard to life and property, they seemed very doubtful; they did not see how it could ever displace the "fire boss" (deputy or underviewer) and his safety-lamp.

The President proposed a vote of thanks to Mr. Wilson for his paper, which was agreed to.

The President proposed that a cordial vote of thanks be given to the owners of collieries to be visited during the course of the meeting, and to the Blyth Harbour Commissioners, the River Tyne Commissioners, and the North Eastern Railway Company, for the steamers and special train placed at the service of the members.

Mr. George May seconded the proposal, which was very cordially adopted.

Mr. Arthur Sopwith proposed a vote of thanks to the North of England Institute of Mining and Mechanical Engineers, for the arrangements which they had made for the reception of the members. The programme of the meeting was an admirable one, and more especially so, as the arrangements confined the members in one party throughout the various excursions.

Mr. Jas. Barrowman (Hamilton) seconded the proposal, and the vote was heartily adopted.

Mr. Forgie moved, and Mr. J. L. Hedley seconded, that their hearty thanks be accorded to the President for his services in the chair.

The President briefly acknowledged the compliment, and the meeting then terminated.

The following notes record some of the features of interest seen by visitors to collieries, etc., which were, by kind permission of the owners, open for inspection during the course of the meeting on September 5th, 6th, and 7th, 1894:—

TYNE COMMISSIONERS' WORKS.

The most important work of the Tyne Improvement Commissioners is the Tyne Piers, the original general plan of which was designed by the late Mr. Walker. Their construction commenced in 1856, under the superintendence of Mr. P. J. Messent, by whom the details of the construction of the works have been designed and carried out. The piers are intended to protect vessels from the frequent and destructive easterly gales, and to facilitate the removal and prevent the re-formation of the bar at the entrance to the harbour. These works, among the most difficult of the kind in progress or executed in any part of the world, on account of the violence of the seas to which they are opposed, are now completed above high-water, and only require protective aprons (now nearly completed) around the heads, formed of heavy (about 36 tons) foreshore blocks, placed by divers at a level of between 20 and 30 feet below low-water. Each pier is formed of a base of rubble stone, deposited from barges, and a superstructure of concrete and masonry, the lower and larger portion of which was fixed by divers, commencing at a depth of 30 feet below low-water. The length of the north pier is 3,053 feet, and that of the south pier 5,310 feet. About 3,000,000 tons of stone, exclusive of lime and cement, have been used in these works. The mammoth cranes, designed by Mr. P. J. Messent, for extending the masonry superstructure of the piers without staging, are capable of setting blocks of weights of upwards of 40 tons, at a distance of 92 feet from the central pivot.

Since the year 1861, the bar at the mouth of the river has been removed to a depth of over 20 feet, which depth is maintained beyond the inner bar for a considerable width in Shields Harbour. The Narrows have been widened from 400 feet to 670 feet. The dangerous shoals have been removed from Shields Harbour, and a depth of at least 30 feet at low-water has been formed for a length of about $1\frac{1}{2}$ miles. The tortuous course of the channel has been straightened, and vessels can leave the river at or within a short time of low-water.

There is now a depth of at least 20 feet between the harbour and Newcastle, where vessels used to ground for several hours at low-water. Two dredgers are still at work continuing a depth of over 18 feet at low-water above Newcastle. Since the commencement of the present year

these improvements have enabled a large number of vessels passing through the Tyne opening bridge to load cargoes of coal at the staiths recently erected by the North-Eastern Railway Company at Dunston.

These improvements have been chiefly effected by dredging. The plant consists of 6 dredgers, 10 steam hopper-barges, 44 wooden hopper-barges, 8 steam tugs, and numerous keels, boats, etc. Over 90,000,000 tons of materials have been dredged from the river, and deposited in the sea two or three miles from the entrance to the river.

At Newcastle, the old bridge of stone, an obstruction to navigation and the flow of the tide, has been removed, and a Swing Bridge constructed. This bridge contains four openings for river traffic, corresponding with those of the High Level Bridge. The two central openings, each of 104 feet, are spanned by a girder, made to swing round and allow masted vessels to pass. The north and south side openings are $92\frac{1}{2}$ and $64\frac{1}{2}$ feet respectively, and available for the passage of vessels with folding masts and funnels. The piers and abutments of the bridge are made of stone and concrete, sunk down to the rock at a depth of 45 feet below low-water. The girder of the swing bridge is 280 feet long, weighs 1,450 tons, and will safely allow the passage of a load of 60 tons on a four-wheeled vehicle.

Friars' Goose Point and Bill Quay Point are in course of removal, by which the width of the river will be materially increased. Bill Point, projecting 400 feet, and involving the excavation of 2,000,000 tons of rock and clay, has been removed. The removal of Whitehill Point, when completed, will widen the river there to the extent of 300 feet.

There are three enclosed docks on the River Tyne. The Northumberland or Howdon Dock has a water area of 58 acres and 24 feet of water on the sill at high tide. It is chiefly used for shipping coal, and is the property of the Tyne Improvement Commission.

The Tyne Dock, belonging to the North Eastern Railway Company, also has a water area of 58 acres, and is chiefly used for shipping coal, of which about 27,000 tons are loaded daily ; the depth on the old sill is $24\frac{3}{4}$ feet at high water, and the new entrance, with greater depth of water, is nearly completed.

The Albert Edward or Coble Dene Dock (for imports and exports) was constructed by the Tyne Improvement Commissioners from the joint design of the late Mr. J. F. Ure and of Mr. P. J. Messent ; it has a water area of 27 acres, and is surrounded by 2,600 feet of deep-water quays. Provision is made for its ultimate extension and junction with the Northumberland Dock, and there is a river wall, 900 feet long in front of

the dock. There is 30 feet of depth at high-water spring tides on the entrance and upper lock sills, and 36 feet on the lower or outer sill of the lock. The average rise of spring tides being 15 feet, the depths at neap tides are 4 feet lower at high-water and 4 feet higher at low-water. On the west quay of the Albert Edward Dock is a large warehouse for grain and general merchandise, 200 feet long by 100 feet broad, containing six floors, each fitted with hydraulic machinery and all necessary appliances. Inside the dock there is a large coal-shipping staith. The Norwegian royal mail and passenger steamers sail every week day between this dock and Norway.

Between the Northumberland and Albert Edward Docks is a riverside wharf 1,100 feet long and 144 feet wide, with quays and standage ground and two warehouses. Above the wharf are two coal-shipping staiths which project 97 feet into the river. The staiths are self-acting ; the loaded wagons descend by gravity to the spouts, and the empty wagons run off the staith to a lower level. Each staith has three spouts, by which coal can be simultaneously loaded into the three hatchways of a large ship at the rate of 800 to 1,000 tons per hour. Eastward of these recently erected are two staiths similarly constructed, but with two spouts each, and a third staith for small coals.

During the year 1891, 11,086,823 tons of coal and coke were shipped from the Tyne, and the volume of general trade, coastwise and foreign, was—

	Tons.
Exports (exclusive of coal and coke)	669,839
Imports	1,666,195
Total	2,336,034

BLYTH HARBOUR.

Blyth harbour is situate at about the centre (measuring north and south) of the Northumberland coal-field, and about 8 miles north of the river Tyne. There are upwards of 20 collieries within a radius of 4 miles, and about 20 others in the neighbourhood, for which Blyth harbour is the natural port of shipment.

There are 14 coaling-spouts at the harbour, most of them being upon the most improved principles, adapted to load into two hatchways of a vessel at one time, and having a depth of water alongside of 29 feet to 34 feet at high-water. The entrance-channel from the sea has a depth of 28 feet at high-water.

By the continuous improvement of the harbour, trade has developed so rapidly that it has been found necessary to provide further accommodation for vessels and greater facilities for shipping coal. The Harbour Commissioners are now increasing the deep-water area of the harbour to the extent of 35 acres, and are providing coaling-staiths capable of shipping 2,000,000 tons of coal per annum, and deep-water import and export wharves with railway-sidings and connexions.

There are quays for the discharge of timber, ballast, and general goods ; five graving-docks for the repair of vessels, and land available for factories, shipbuilding-yards, etc. Both sides of the harbour are connected with the North Eastern Railway system, and with all parts of the country.

The shipments of coal at the harbour during a few recent years are as follow :—

From November 1st,	1882,	to October 31st,	1883,	146,264	tons.
,,	,,	1883,	,,	,,	1884,	362,879	,,
,,	,,	1884,	,,	,,	1885,	526,667	,,
,,	,,	1885,	,,	,,	1886,	561,749	,,
,,	,,	1886,	,,	,,	1887,	585,484	,,
,,	,,	1887,	,,	,,	1888,	1,018,335	,,
,,	,,	1888,	,,	,,	1889,	1,263,327	,,
,,	,,	1889,	,,	,,	1890,	1,715,406	,,
,,	,,	1890,	,,	,,	1891,	2,047,480	,,
,,	,,	1891,	,,	,,	1892,	2,157,140	,,
,,	,,	1892,	,,	,,	1893,	2,342,020	,,

ASHINGTON COLLIERY (BOTHAL WEST HARTLEY).

This colliery has an output of about 4,300 tons of coal per day.

There are three shafts situated together near Ashington Station which form one establishment, with a daily output of about 4,000 tons of coal. The depth of the shafts to the low main seam is 540 feet.

The underground haulage is on the endless-rope system, and the workings are carried to the dip 340 feet below shaft-level. The underground pumps are in part worked by compressed air and in part by endless-ropes, upwards of 18 miles of ropes being in daily use for these purposes.

The feeders of water are raised to the surface by pumps 25 inches in diameter, delivering 1,100 gallons per minute. A supply of pure water for the inhabitants of the village is forced to the surface by independent machinery in duplicate, so that the supply may be continuous in case of accident.

Steam is supplied by twenty boilers fitted with automatic stoking bars and forced-draught furnaces.

The electric light is supplied in several of the departments.

Vibrating screens and travelling-belts are employed in preparing the coal and separating it as required for the market. A Bell and Ramsay washer is also in use.

The coal supply to the workmen and others and the scavenging of the colliery village are worked by means of narrow-gauge railways, of which there are upwards of 6 miles.

Bricks are being made from fire-clay by the semi-dry process.

CAMBOIS COLLIERY.

The low main seam is being worked at a depth of 630 feet. The seam is 4½ to 5 feet in height, and is worked on the board-and-pillar system. The output is about 1,200 tons per day, the greater portion being worked from the undersea area.

The vertical condensing winding-engine has one cylinder 65 inches in diameter and 7 feet stroke. The drum is 22 feet in diameter. It draws 4 tubs at once, each of the gross weight of 21 cwts.

The haulage, on the main-and-tail-rope system, is effected by 3 semi-portable engines (underground). The cylinders are 14, 14, and 12 inches respectively in diameter, and the drums 6 feet in diameter.

The underground pumping-engine has 2 cylinders, each 22 inches in diameter and 5 feet stroke, rams 9 inches in diameter, forcing 400 gallons of water per minute to a vertical height of 650 feet, through pipes 13 inches in diameter.

The electric pumping-plant (at bank) consists of a Robey trip-gear engine and a 40 unit Tyne dynamo, which drives 6 underground pumps at distances of 3,600, 5,400, 5,700, 6,600, and 6,900 feet from the shaft. The pumps are 6 and 8 inches in diameter, 18 inches stroke, and are connected by worm-gearing to 6 horse-power motors. The total length of electric cable in use is nearly 8 miles.

There is also an electric lighting plant, and a Robinson coal-washer of 250 tons capacity.

The colliery is connected by private line with the company's shipping spouts at North Blyth.

NORTH SEATON COLLIERY.

The seams worked are the yard and low main, at the depths of 558 and 750 feet respectively. The yard seam is 2½ to 3 feet in thickness, and is worked on the longwall system. The low main seam is 4 to 5 feet in height, and is worked on the board-and-pillar system. The output is about 1,100 tons per day.

The vertical condensing winding-engine has a cylinder 60 inches in diameter and 7 feet stroke. The drum is 22 feet in diameter. It draws 4 tubs at once, each of the gross weight of 21 cwts. An endless-rope counterbalance is used under the cages in the shaft.

The haulage on the main-and-tail-rope system in the low main seam is effected by an horizontal engine, placed underground, with two cylinders, each 20 inches in diameter, and 30 inches stroke. The drums are 8 feet in diameter. The endless-rope system is in use in the yard coal-seam, gravitating to the shaft through a drift to the low main seam.

A compound condensing Worthington pumping-engine, placed underground, is forcing 750 gallons of water to a vertical height of 800 feet, through a wrought iron main, 10 inches in diameter. The high-pressure cylinders are 18 inches in diameter, the low-pressure cylinders are 30 inches in diameter, the rams are 9 inches in diameter, and 30 inches stroke. A vertical beam pumping-engine, on the surface, held in reserve, with a cylinder 78 inches in diameter and 6 feet stroke, works pumps 26, 20, and 18 inches in diameter.

The electric pumping-plant comprises an engine at bank, with a cylinder 13 inches in diameter and 10 inches stroke, driving a Tyne dynamo, connected by concentric cable to an underground pump 8,000 feet distant. The three-throw pump is worked by means of worm-gearing; the rams, 9 inches in diameter and 15 inches stroke, are pumping about 250 gallons of water per minute.

The screening plant comprises jigging screens, picking-belts, mechanical tipplers, 200 tons Robinson coal-washer, etc.

There is also an electric lighting plant.

NEW HARTLEY COLLIERY.—HASTINGS PIT.

The shaft, 16 feet in diameter, is sunk 330 feet to the yard coal-seam, which is worked on the longwall system.

The horizontal winding-engine has two cylinders, each 28 inches in diameter, and 54 inches stroke; fitted with drum, 14 feet $4\frac{1}{2}$ inches in diameter. The cages have two decks, carrying 4 tubs, each containing $8\frac{1}{2}$ cwts. of coals.

The horizontal hauling-engine (underground) has two cylinders, each 18 inches in diameter and 36 inches stroke; it is geared $2\frac{1}{2}$ to 1, and is working an endless-chain system of haulage. Steam is passed to this engine from the surface.

The compound differential pumping-engine on the surface has cylinders 24 inches and 44 inches respectively in diameter, and 7 feet stroke. There are two rams at the pit-bottom, each $17\frac{1}{2}$ inches in diameter, and of the same stroke, worked by means of quadrants and spears. About 500 gallons per minute are now forced to a vertical height of 384 feet, but the engine has pumped 1,570 gallons per minute.

The colliery is ventilated by a Guibal fan, 30 feet in diameter producing 108,000 cubic feet of air per minute, under a water-gauge of 1·30 inches.

Electric lighting is applied on the surface and underground.

The Melton pit, 13 feet in diameter, 336 feet to the yard coal-seam, is being sunk to the low main seam.

SEGHILL COLLIERY.

The output of about 1,200 tons of coal per day is drawn from two shafts.

The colliery is ventilated by an open-running fan 35 feet in diameter. The fan is driven by a Corliss engine having one steam cylinder 16 inches in diameter and 3 feet stroke, with sugar-tongs clip valve-gear. The engine is controlled by a governor which automatically varies the cut-off and maintains a regular speed even when the steam pressure varies 20 lbs. per square inch. The speed is readily varied by altering weights placed on the governor, and this change can be effected while the engine is running.*

Revolutions of Fan per Minute.	Volume of Air per Minute.	Indicated Horse-power of Fan Engine.	Steam Used.			Small Coal Used per Year of 365 Days.
			Per Indicated Horse-power per Hour.	Per Day.	Per Year of 365 Days.	
	Cubic Feet.		Lbs.	Tons.	Tons.	Tons.
40	87,940	29·61	35·57	11·281	4,117	560
60	135,742	96·11	27·12	27·927	10,193	1,437

A vertical engine, with a cylinder $9\frac{1}{2}$ inches in diameter, 9 inches stroke, running at 200 revolutions per minute, drives a 15 horse-power dynamo producing a current of 460 volts. The electric energy is transmitted through a 7/16 insulated cable to a 10 horse-power motor placed in the low main seam, nearly a mile distant from the shaft. This motor drives a three-throw ram-pump delivering 100 gallons of water per minute

* *Trans. Fed. Inst.*, vol. vi., page 48.

to a vertical height of 120 feet through two pipes 4 inches in diameter. The useful effect is 32 per cent.* A few electric incandescent lights are attached to this dynamo.

The haulage, on the main-and-tail-rope system, is worked by a horizontal engine, with a cylinder 13½ inches in diameter and 30 inches stroke; the cylinders are steam-jacketted, and fitted with valve-gear, controlled by a governor, which automatically varies the cut-off, and maintains a constant speed of engine. The speed may be varied from 70 to 100 revolutions per minute by altering a spring attached to the governor, even while the engine is in motion. When not hauling, the tail-rope drum can be put out of gear, a clip-wheel put into gear, and the power transmitted by an endless wire-rope to the main pumping-engine in the low main seam. This engine, when running at 70 revolutions per minute, indicates 66 horse-power, and pumps 200 gallons of water per minute from a depth of 510 feet.

A similar engine works the endless-rope haulage in the yard seam with over 2 miles of rope. A smaller engine, with a cylinder 10½ inches in diameter and 22 inches stroke, works the endless-rope haulage in the blake seam with over 6 miles of rope.

All these engines are worked by steam at a pressure of 100 lbs. per square inch, and the steam for the whole of the collieries is generated by four Lancashire boilers, fired by hand with small coal.

THE EXPERIMENTAL EXPLOSIVES STATION OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

The North of England Institute of Mining and Mechanical Engineers have been conducting for some months, at their own expense, important experiments on flameless high explosives.

The labours of the committee have been up to the present time directed to the behaviour of ammonite, ardeer powder, bellite, carbonite, roburite, and securite, when fired into mixtures containing from 1 to 10 per cent. of mine-gas or coal-gas.

The experiments are being conducted in a large shed, which is singularly appropriate to the purpose to which it is now applied. The firing-chamber consists of a cylindrical tube, 100 feet long and 3 feet in diameter, made of boiler plates, and a cannon, mounted on a carriage and

* *Trans. Fed. Inst.*, vol. iv., page 132.

capable of being brought close up to one end of the chamber, serves for holding and firing the charge of explosive. The chamber has safety-vents placed at intervals along the top, which are closed by wooden plugs loosely knocked in, and, in addition, there are numerous sight-holes, glazed with thick glass, for observing the interior. There are other arrangements: for ensuring the delivery of a measured volume of gas into a definite volume of air; for effecting the perfect admixture of the gaseous mixture; for taking samples of the mixture before or after ignition; for taking its temperature; for providing for the presence of dust of any kind in suspension, or *in situ;* and for other purposes, all of which indicate how carefully and thoroughly the investigations have been planned and executed by the committee of the Institute.

The experiments shown to the visitors included the firing of blasting-powder into ordinary air; into an inflammable mixture of natural fire-damp and air; into ordinary air with coal-dust in suspension; and into ordinary air with coal-dust *in situ.* Before commencing any experiment, the far end or mouth of the firing-chamber was covered with a sheet of brown paper.

In the air, with gunpowder alone, a bright flash was observed in the chamber, and the brown paper was blown off the end of the tube; when coal-dust was present, whether in suspension or *in situ,* the flash was considerably brightened and lengthened, and not only was the brown paper blown off the end of the tube, but a huge cloud of smoke was propelled for a distance of more than 100 feet beyond the mouth of the tube, and many of the plugs were forcibly projected from the safety-vents, being followed by rushing columns of thick black smoke, and in some instances by flame; very suggestive of the inflammability of mixtures of coal-dust and air.

The force of an ignition of fire-damp and air was equally well exhibited, and in this case two flashes were observable, the first being due to the ignition of the blasting-powder, the second to the ignition of the gaseous mixture.

The experiments were very successfully carried out by Mr. A. C. Kayll the engineer to the committee, all points being clearly explained, and the apparatus lucidly described by Mr. J. L. Hedley, H.M. Inspector of Mines.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 13TH, 1894.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous General Meeting, and reported the proceedings of the Council at their meetings on September 29th and that day.

The proceedings of the Council of The Federated Institution of Mining Engineers were reported.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WILLIAM HENRY ANGOVE, Engineer, Albany, Western Australia.

Mr. JAMES FORD DAVISON, Mining Engineer, Yarlside, Dalton-in-Furness.

Mr. JONATHAN DIXON, Colliery Manager, Homeville, West Maitland, New South Wales.

Mr. JOHN THOMAS FOULIS, Mine Agent, 42, Demesne Road, Douglas, Isle of Man.

Mr. GEORGE C. HOOPER, Surveyor of Mines, Whitehaven Collieries, Whitehaven.

Mr. HENRY THORNTON NEWBIGIN, Engineer and Manager, c/o Messrs. M. Coulson & Co., Spennymoor.

Mr. HORACE PRATT, Colliery Manager, Jobs Hill, Crook.

Mr. JAMES RUSSELL, Mine Manager, etc., Ukalunda, via Bowen, Queensland.

Mr. CHARLES TURNER SANER, General Manager, Van Ryn Estate and Gold Mining Co., Limited, P.O. Box 357, Johannesburg, Transvaal.

Mr. GEORGE A. SPOTSWOOD, Mining Engineer, 46, Clarence Street, Kingston, Ontario, Canada.

Mr. THOMAS PRESSICK YEOMAN, Mining Engineer, Bengal Coal Co., Giridih, Bengal, India.

ASSOCIATE MEMBERS—

Mr. BENJAMIN ROBINSON BANYER, Mining Student, School of Mines, Kapunda, South Australia.

Mr. EDWARD ECCLES, King Street, Newcastle-upon-Tyne.

Mr. RICHARD JOHN MIDDLETON, Manager of the *Mining Journal*, 18, Finch Lane, London, E.C., and The Lilies, Balfour Road, Highbury New Park, London, N.

Mr. B. J. Townsend, Toronto, Ontario, Canada.

Mr. Arthur Watson, Mining Student, Hamsterley Colliery, Ebchester, Co. Durham.

Mr. John Weatherburn, Draughtsman, 53, Cuthbert Street, Gateshead.

Associates—

Mr. Thomas Battey, Overman, Percy Terrace, Backworth Colliery.

Mr. William Ralph Bell, Assistant Under-manager, Wearmouth Colliery, Sunderland.

Mr. Joseph Stanley Cowell, Assistant Under-manager, Wearmouth Colliery, Sunderland.

Mr. Thomas Proctor, Overman, Ashington Colliery, Northumberland.

Mr. Joseph C. Southern, Master Wasteman, Harraton Colliery, Washington, R.S.O., Co. Durham.

Students—

Mr. Edward Herbert Clifford, Mining Student, 24, Gledstanes Road, West Kensington, London. S.W.

Mr. Michael Falcon, Mining Student, Thwaites' Parsonage, Millom, Carnforth.

Mr. James Arthur Imeson, Articled Apprentice, Wearmouth Colliery, Sunderland.

Mr. Ernest McGowan, Articled Apprentice, Wearmouth Colliery, Sunderland.

Mr. H. G. Raeburn, Mining Student, Redheugh Colliery, Gateshead.

Subscribing Member—

Messrs. John Mills & Sons, Limited, Collingwood Street, Newcastle-upon-Tyne.

The following gentlemen were nominated for election :—

Honorary Member—

Mr. William Garnett, M.A., D.C.L., 13, Spring Gardens, London, S.W.

Members—

Mr. B. Angwin, Mining Engineer, P.O. Box 231, Johannesburg, Transvaal.

Mr. George Bellingham, Licensed Land and Mining Surveyor, Coolgardie, Western Australia.

Mr. Alfred Hammond Bromly, Mining and Mechanical Engineer, Llannwchllyn, near Bala, North Wales.

Mr. Ronald C. Campbell-Johnston, Metallurgist, Assayer, and Mining Engineer, P.O. Box 40, Vancouver, British Columbia.

Mr. Henry Reynolds Chapman, Mechanical Engineer, Victoria Works, Gateshead-upon-Tyne.

Mr. Robert Edden Commans, Mining Engineer, 6, Queen Street Place, London, E.C.

Mr. Richard Stafford Cousins, Civil Engineer, Coach Road House, Whitehaven.

Mr. Robert Fowler, Colliery Manager, Washington Colliery, Washington Station, R.S.O.

Mr. Henry Richard Hancock, Superintendent, Wallaroo and Moonta Mines, Moonta Mines, South Australia.

Mr. Reiji Kanda, Mining Engineer, c/o Mr. Takahira Kanda, 9, Awajicho-Nechome, Kanda, Tokio, Japan.

Mr. H. W. Ferd Kayser, Mining Engineer, The Mount Bichoff Tin Mining Company, Waratah, Tasmania.

Mr. William Leck, H.M. Inspector of Mines, Cleator Moor, Cumberland.

Mr. Duncan McGeachie, Manager, Waratah Colliery, Charlestown, near Newcastle, New South Wales.

Mr. D. H. F. Matthews, H.M. Inspector of Mines, Newton-le-Willows.

Mr. James Jones Meldrum, Manufacturing Engineer, Atlantic Works, City Road, Manchester.

Mr. Septimus Oliver, Mining Engineer, Tyne House, Tynemouth.

Mr. Frederick Danvers Power, Mining Engineer and Metallurgist, c/o Messrs. Henderson & Macfarlane, 2, Bridge Street, Sydney, New South Wales.

Mr. William Edward Sam, Jun., Mining Engineer, c/o Messrs. F. & A. Swanzy, Cape Coast Castle, Gold Coast.

Mr. Harry Sladden, Mining Engineer, Chorlton Chambers, P.O. Box 1666, Johannesburg, Transvaal.

Mr. George Paton Walsh, Engineer, 138, Reguliersgracht, Amsterdam, Holland.

Mr. Horace V. Winchell, Geologist and Mining Expert, 316, Tenth Avenue, S.E., Minneapolis, Minn., U.S.A.

Associate Members—

Mr. Alfred Molyneux Palmer, Coal Owner, 14, Windsor Terrace, Newcastle-upon-Tyne.

Mr. Sydney C. Rudman, Land Agent and Engineering Surveyor, Estate Office, Windlestone, Ferryhill.

Mr. Robert Sheard, Engineer and Boiler Builder, Caldervale Boiler Works, Wakefield.

Mr. G. Young Wall, Manorial Surveyor and Local Deputy Steward to the Ecclesiastical Commissioners for England, Halmote Court Office, New Exchequer Buildings, Durham.

Associates—

Mr. Arthur Morton Hedley, Assistant Overman, Barrow Collieries, Barnsley.

Mr. James Stokoe, Overman, Murton Colliery, *via* Sunderland.

Students—

Mr. John Henry Bacon Forster, Mining Student, Hetton Colliery, Hetton-le-Hole, R.S.O.

Mr. Nathaniel Maurice Griffith, Mining Student, c/o Broughton & Plas Power Coal Co., Ld., Wrexham.

Mr. Tom Alfred Lishman, Mining Student, The Tower, Durham.

Mr. Albert Littlejohn, Mining Student, Ashington Colliery Offices, Morpeth.

Mr. Philip Neasham, Mining Apprentice, Colliery Office, Medomsley, Co. Durham.

Mr. Norman Nisbet, Mining Apprentice, Tantobie, Co. Durham.

AWARDS FOR PAPERS.

The SECRETARY read the following list of papers read during the year 1893-94, for which prizes had been awarded by the Council to the authors:—

"A Contribution to our Knowledge of Coal-dust. Part II." By Dr. P. Phillips Bedson.
"A Contribution to our Knowledge of Coal-dust. Part III." By Dr. P. Phillips Bedson and Mr. W. McConnell, jun.
"The Combustion of Oxygen and Coal-dust in Mines." By Mr. W. C. Blackett.
"History and Description of the Greenside Silver Lead Mine, Patterdale." By Mr. W. H. Borlase.
"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.
"The Ghorband Lead-mines, Afghanistan." By Mr. A. L. Collins.
"Note on the Antimony Deposit of El Altar, Sonora, Mexico." By Mr. Edward Halse.
"Note on the Occurrence of Mercury at Quindiú, Tolima, U. S. Colombia." By Mr. Edward Halse.
"Mining Explosives: Their Definition as Authorized under the Explosives Act, 1875." By Mr. A. C. Kayll.
"Miss-fires." By Mr. J. D. Kendall.
"Singareni Coal-field, Hyderabad, India." By Mr. J. P. Kirkup.
"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.
"Historical Sketch of the Whitehaven Collieries." By Mr. R. W. Moore.
"Magnetic Declination and its Variations." By Prof. H. Stroud.
"Minerals and Mining in Tasmania." By Mr. A. P. Wilson.

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, OXFORD, 1894.

The report of the proceedings of the Corresponding Societies' Committee of the British Association was read, and of Prof. J. H. Merivale, the delegate of the Institute, as follows:—

NEWCASTLE-UPON-TYNE,
AUGUST 25TH, 1894.

TO THE PRESIDENT AND COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

DEAR SIRS,

I went to Oxford on the 8th instant as the representative of the North of England Institute of Mining and Mechanical Engineers. Unfortunately, the sudden death of Mr. Scott called me home before the conclusion of the meeting, and I was therefore unable to attend the second conference of delegates and several of the sectional meetings. But through the courtesy of friends and a study of the accounts in the scientific papers I am able to make a full report.

The first conference of delegates of the corresponding societies was devoted to the consideration of local natural history museums, how the specimens may be best arranged, preserved, catalogued, and made generally more useful.

At the second meeting, the report of the committee on earth-tremors was discussed, more particularly with reference to Mr. Horace Darwin's bifilar pendulum. It would seem that the bifilar pendulum is admirably adapted for measuring the minute changes of level, which are perhaps the cause of some of the uneliminated errors in many astronomical and physical inquiries. Again, the bendings of the earth's crust by changes of barometric pressure, by the ebb and flow of the tides, etc., may be studied, as well as the long-period pulsations produced by violent earthquakes in almost any part of the world. It is not too much to expect, also, that in time we may be able to trace out and measure the slow secular movements of the earth's crust which, after the lapse of ages, become perceptible to the geologist; and that the vexed question of the origin of lake-basins may receive an answer that will remove this most debatable of subjects from the domain of controversy for ever.

There was also a discussion upon the report of the underground waters committee.

Several papers of interest were read in the various sections; among which may be mentioned a paper upon the "Chemistry of the Coal-formation," by Mr. J. W. Thomas, of Gloucester. The author said that the age of the coal and the physical conditions, such as the effect of water, heat, and pressure, should throw light upon the chemistry of coal-formation; but the coals in one coal-field are found under different physical and chemical conditions from those in another, and little evidence is obtained by comparison. The decomposition of peat and wood to-day teaches the chemistry of coal-formation. In both instances the woody fibre disappears first, leaving a residue richer in resinoids. The lignites of Bovey Tracey have, as in the case of decaying peat and wood, an excess of resinoid matters over the vegetation which formed them. Mr. Hutton found mineral resin in carboniferous coals, and others have done so since. Mr. Witham showed long ago, and much recent evidence proves, that conifers and other dicotyledons flourished during the Carboniferous period. Just as lime and other trees shed saccharine matter on the leaves and grass underneath, so it is probable that liquid, gummy, and resinous matters were showered from the forest vegetation during the Carboniferous and Tertiary periods. The chemical changes in coal-formation took place chiefly at and near the surface. In the formation of paraffin-shale and some Scotch cannels the woody fibre of the forest-growths was destroyed, little else but bituminous matters remaining. A resinous vegetation without much dicotyledonous trees, or, if with dicotyledons, considerable surface exposure and decomposition of the woody fibre, would produce rich bituminous coal, cannel, etc. A luxuriant resinous and dicotyledonous vegetation without much surface-decomposition probably gave rise to semi-bituminous, steam, and anthracite coal, assisted by heat and pressure. Further investigations are necessary, and in particular a study of the hygroscopicity of coal might throw considerable light on the spontaneous combustion of coal on board ships.

Dr. Haldane read a paper on "The Causes and Prevention of Suffocation in Mines," in which he described the practical importance of the investigation, and brought forward evidence that about 75 per cent. of the deaths after a large colliery explosion were due to suffocation. This was against the evidence generally given at inquests. At these inquiries about 70 per cent. of the deaths were attributed to injuries due to the force of the blast, and only about 30 per cent. to the suffocation by after-damp. He discussed the composition of the gases found in mines which caused death by suffocation, and remarked that he was very much surprised to find that articles on these gases in chemical books were of a slovenly

character. He distinguished between the qualities of fire-damp, black-damp, and white-damp. Fire-damp consisted for the most part of marsh gas, and it was only rarely that it played any part in suffocation, though there were instances of miners being rendered insensible by it. The popular idea was that black-damp was composed almost entirely of carbonic acid gas; but analyses showed that there was in it only about 10 per cent. of carbonic acid gas, and that the rest of it was nitrogen. He thought that the deadly qualities of black-damp were due, not to the presence in it of carbonic acid gas, but to the absence of oxygen. This had been practically demonstrated in the laboratory, and Dr. Haldane showed one or two experiments and a number of diagrams, on which were represented the positions of bodies found after explosions in mines, proving that many of the men had, after the explosion, travelled long distances, to be at last overcome by the fumes of the after-damp. White-damp got its name from the fact that it frequently presented the appearance of white steam. This was frequently formed from the combustion of gunpowder, and he referred in this connexion to an accident which occurred some years ago on the shores of Loch Fyne, where a party of excursionists going into a quarry after an explosion were overcome by the fumes of the products of combustion. He had analysed white-damp, and found that the deadly components in it were carbonic oxide and sulphuretted hydrogen. The practical question was, could any means be devised whereby the miners who were not killed by the blast of an explosion could be kept alive for an hour or two, so as to give them a chance of getting into the main ways, which might still have sufficient oxygen in them to maintain life? The lecturer exhibited a little box which he had devised, the principal part of which consisted of a cylinder of compressed oxygen, an apparatus being attached to it by which the miners, under the circumstances already referred to, might breathe oxygen, and be thus saved from the effects of the choke-damp.

Dr. Shaw Lyttle, in his paper on "The Effects of After-damp," said that he descended with the third exploring party after the explosion at the Albion colliery, and was engaged in ministering to the needs of the survivors. He described the exact localities in which the survivors were found, in relation to the places where they were working at the time of the explosion, and also the symptoms which they exhibited. Along the Cilfynydd level, the bodies were much burned and mutilated where the largest fall of roof had occurred. One survivor in the dip seemed quite dazed; he knew no one, could not articulate, and did not appear to comprehend why a stimulant was put to his mouth. Some men were lying down and had the appearance of suffering from an ordinary epileptic attack; they were frothing at the mouth, and one was tossing violently from side to side and striking his head against the ground. One was sitting up and groaning. Only two or three were able to swallow the stimulant offered them. In the Pantddu dip, thirty bodies were found, all asphyxiated. In Dudson's dip, off the Grover level, thirty-seven bodies of men were found. Of seventy bodies examined, eleven died immediately from burns; twenty-two from asphyxia; nineteen from burns and asphyxia, but who, without after-damp, would probably have succumbed subsequently; six from violence irrespective of burns; twelve from violence and burns, but in some of these asphyxia may have had a part. Dr. Lyttle added the observations of rescuers. Some felt smarting of the eyes and attributed it to dust. Some did not perceive any smell of burning, others did; one said of wool, another of matches, a third said it was "sulphury." The survivors in the Grover level, according to one rescuer, drank water greedily, but when brought out of the pit they seemed to lose consciousness, and could not answer questions so readily as before.

Professor Kennedy devoted his presidential address, in the mechanical section to "The Critical Side of Mechanical Training." He considered that in cases where

a university or university college takes in hand the preparation of engineers (and he hopes that such cases will grow in number), they should provide for them special training in mathematics, and probably also in physics, distinct from the general training in these subjects most suitable for degrees.

Mr. R. H. Hooker read a paper on "The Relation between Wages and the Numbers employed in the Coal-mining Industry," and said that the influence of wages in attracting labour to an industry was best shown by means of a diagram, and the industry concerning which we possessed the most trustworthy statistics of wages and of the numbers employed over a series of years was undoubtedly coal-mining. The data concerning this occupation had accordingly been plotted on a diagram, in which one line represented the course of wages from 1871-91 in the county of Durham (according to the evidence of Mr. Lindsay Wood before the Labour Commission), while another line showed the number of persons employed in coal-mining in the same county (taken from the annual reports of H.M. Inspectors of Mines). The wages were expressed in percentages above or below the rate paid in 1871. The correspondence of the two curves was very apparent, and, judging by the magnitude of the fluctuations, it would seem that the variations in the number of the employés must be attributed almost entirely to the changes in wages. Especially the very large increase of miners in 1872-74 and 1889-91 could hardly be ascribed to any other cause than to the attraction of the great rise in wages at those periods. It must be remembered that the coal-mining industry was in many respects peculiar, the organisation of the men was very complete, and the principle of the sliding scale was everywhere in force, even in those districts where a scale did not actually determine the wages. These latter being then dependent on prices, employers could not lower their rate of pay when the supply of labour was unusually large, nor could they raise the remuneration unless there was a corresponding change in the price of coal. It would seem, then, that the numbers depended on the wages. It did not follow that this condition prevailed in every occupation, but it was probable that, according as the organization of the men in any industry was more complete, there was a greater tendency in that industry for the numbers employed to follow the wage.

Yours faithfully,

JOHN H. MERIVALE.

DISCUSSION ON DR. P. PHILLIPS BEDSON AND MR. W. McCONNELL, JUN.'S, PAPERS ON "A CONTRIBUTION TO OUR KNOWLEDGE OF COAL-DUST.—PARTS II. AND III."*

The PRESIDENT said that the Institute owed a debt of gratitude to Dr. Bedson and Mr. McConnell for the pains which they had taken to instruct the members on this important subject.

Dr. BEDSON said that there was only one point in connexion with the subject on which he would like to say a word. There was perhaps to some minds very little that was novel in the fact that coal-dust should resemble coal so nearly, and many minds in approaching the subject seemed to think that as coal—as proved by Messrs. Thomas and Meyer—contained combustible gases, coal-dust would do so too. But to

* *Trans. Fed. Inst.*, vol. vii., pages 27 and 32.

him it appeared necessary, although one might assume that coal-dust would resemble coal, to establish this by experiments ; and the attitude of mind which regarded these contributions as foregone conclusions from the knowledge they already had of coal, was something of the same kind as that of the philosopher who forms a system of the universe by sitting quietly in his study. He wished simply to make these remarks in justification of some of the criticisms which had been made on the work covered by these papers. To his mind it was absolutely essential to demonstrate that coal-dust did hold enclosed gases. The experiments that had been recorded, demonstrated that certain coal-dusts yielded no inflammable gases, while others were remarkable for the high proportion which they contained. In connexion with this work he had been recently studying the report of Mr. Henry Hall's experiments, made for the Royal Commission on Explosions from Coal-Dust in Mines, and he expected to have obtained from it some light as to the behaviour of coal-dusts. He found that Mr. Hall's investigations included coal-dust from the same seams and representing the same dusts as those which Mr. McConnell and himself had submitted to exhaustive treatment. Mr. Hall succeeded in obtaining an explosion with almost every coal-dust investigated, but what he (Prof. Bedson) hoped to find in Mr. Hall's experiments was an indication that coal-dusts like those of the hutton and low main seams in Durham and Northumberland, which they had found to be remarkable for the high proportion of combustible gases they enclosed, would differ from such dusts as those obtained from Brancepeth, and other dusts which were remarkable for the complete absence of these inflammable gases.

The PRESIDENT asked what was the lowest temperature to which coal-dust had been submitted, and gas found to exude ?

Dr. BEDSON replied that the lowest was 86 degs. Fahr., but all of his experiments were of course under reduced pressure, practically in a vacuum.

The PRESIDENT remarked that the temperature in deep mines would probably be about 86 degs. Fahr. or less.

The discussion was then closed.

Mr. SIMON TATE read the following paper on "Saving of Life from After-damp, Smoke, or Fumes in Mines":—

SAVING OF LIFE FROM AFTER-DAMP, SMOKE, OR FUMES IN MINES.

By SIMON TATE.

It has been the writer's painful duty on several occasions to be one of an exploring party in a coal-mine after an explosion. Every explosion makes one acquainted with the fact that many, if not the greater, portion of the lives sacrificed are not lost by the force and violence of the explosion, or by direct contact with the flames or heat, but from inhaling the deadly after-damp. The proportion of deaths due to this latter cause is said to exceed twice the number of those killed by the force or heat of the explosion.

At the recent explosion at the Albion colliery the proportion of deaths due, altogether or partly, to the inhaling of the after-damp was stated by Dr. J. Shaw Little to be 58 per cent., but he had only examined 70 bodies. He also stated that 30 bodies were found in one place and 37 in another, all of which deaths were caused by the after-damp.

If the workmen left alive and uninjured by the force of an explosion could be rescued, colliery explosions would be deprived of some of their most terrible consequences, and the number of lives lost would be considerably diminished.

The writer has often thought that the very means adopted to reach the imprisoned men after a mine explosion has literally shortened their lives by forcing upon them the silent and deadly after-damp.

There have been frequent instances after an explosion where workmen have been left alive and uninjured in remote portions of the mine, often so far distant that they were scarcely aware that anything serious had occurred, except from hearing a slight rumbling sound, or noticing an alteration or cessation of the air-current; yet they have, after hours and even days of anguish and uncertainty, at last died owing to the after-damp penetrating the portion of the mine in which they were.

A case is recorded where a workman was in a mine in which an explosion occurred, but at such a distance from the direct effects of the explosion as to be uninjured. He took refuge between two trap-doors, which he endeavoured to make air-tight. He so far succeeded that he

lived for a considerable period after every one else in that portion of the mine had succumbed. He left a record in chalk upon one of the doors, showing that he was able to withstand the effects of the after-damp for a considerable length of time, and had there not been a "standing fire," which presumably necessitated the sealing-up of the mine, this man would in all probability have been rescued alive.

These and other considerations have led the writer to devise some practical means of overcoming this serious danger. He is aware that it has been suggested to have *ports-d'abris* (*i.e.*, safety-cabins, hermetically sealed, but connected by ranges of pipes, telephonic communication, etc., with the surface, etc.). In many cases the use of such contrivances are, to say the least, impracticable, because the out-bye roads and shafts are completely wrecked. These facts, together with the great cost of their erection and maintenance is undoubtedly the reason why similar contrivances have not been adopted.

The writer's idea is that any person who may be situated in a portion of a mine at the time of an accident, either from explosion or fire, and whose passage to the shaft or outlet is cut off either by after-damp or smoke, should have a means provided by which he can isolate or separate the district, or a portion of it, from the other portions of the mine affected by the accident. To do this the writer proposes that close-fitting doors should be placed in a suitable position upon the intake and return air-ways, and also that relief-doors or slides should be placed in the holings between the intake and return air-ways immediately on the out-bye side of the before-mentioned doors.

The accompanying and somewhat ideal plan, Fig. 1 (Plate XIII.), illustrates the writer's suggestion:—A and B represent districts worked by the bord-and-pillar system, C and E long-wall districts, and F and G are wide-wall and double-stall districts respectively. In cases of emergency, any person finding he was in danger of losing his life by foul air penetrating into that portion of the mine could immediately establish communications between the intake and return air-ways (on the out-bye side of whatever position the doors might be placed) by opening the slides of the doors *d* fixed in the stentons or holings.

It will be observed that any of these districts can be completely isolated from the other districts, by closing doors fixed at the points D. Any person on the in-bye side of such doors when closed would then be entirely separated from the dangerous atmosphere resulting from an explosion or fire, and he would be able to exist for a considerable period upon the air confined on the in-bye side of these closed doors.

The panel system of working offers peculiar facilities for carrying out the writer's suggestion, and faults or troubles crossing the airways could be utilized as barriers to isolate a portion of the mine. In long-wall workings, a range of gateways could be carefully and closely stowed, and thus form a barrier without loosing or leaving any coal. (See E, Fig. 1, Plate XIII.) In fact there is no practical difficulty to prevent its adoption under any of the more general methods of working mines.

Some of the advantages that would probably accrue by the adoption of the proposed system may be enumerated as follows :—

(*a*) The certainty of the persons so isolated not being reached by the after-damp or smoke for a length of time after the explosion or fire, sufficient in many cases to allow of their rescue.

(*b*) The restoration of air-currents and the clearing away of the after-damp or smoke would be facilitated by the shortened length of air-ways.

(*c*) The early ascertainment that persons had survived the force of the explosion (shown by the doors being closed) and were probably still alive on the in-bye side of the doors, waiting to be rescued.

Even if it be thought unnecessary to adopt this plan in its entirety, it might be desirable that favourable positions should be pointed out to the workmen by the officials of the mine, and that material should be conveniently placed for fixing stoppings in the intake and return air-ways, so as to prevent the after-damp or smoke reaching or penetrating any isolated area.

Mr. A. L. Steavenson said that they all knew the old proverb that "Prevention was better than cure," and if they were not able to prevent explosions, the next best thing was to minimize the effects as much as possible, and Mr. Tate had made valuable suggestions with that object. Coming from such a practical man as Mr. Tate, his proposals demanded their very serious consideration. No doubt Mr. Tate was well aware as to the difficulties of applying his proposals ; one of the first difficulties was that after an explosion all the stoppings were blown out and the roof fallen down, everything was in such a condition that, even if they got to his proposed safety-doors, they would not move. But the great difficulty would be in getting to the places, and travelling over falls, etc., so as to reach them. Another point was that most of the mines in the

North of England were old mines, and it would be difficult to apply the system except to new portions of the mine. He would not like at present to express an opinion on the subject. Refuge-places had been frequently recommended, and Col. Shakspeare had recommended refuges communicating with the surface by means of boreholes.

The PRESIDENT said that within his own experience he remembered life being saved by a workman in a confined part of the mine erecting a stopping on his own responsibility, at the end of the place in which he was working—100 feet away. He (the President) agreed with Mr. Steavenson that Mr. Tate's proposals were especially applicable to new mines. It was very useful to know Mr. Tate's views on a question of this kind, but he did not know that he could quite follow him further than to think that a workman might do something intelligently to assist in saving life in cases of emergency. A knowledge of the mine in such instances was also essential, so as to enable him to use proper means with safety to himself.

Mr F. BERKLEY thought that if the force of the explosion was sufficient to break down the stoppings and doors, it would be sufficient to kill the workmen, in which case the proposed method would be useless; he thought, however, that most collieries would have some districts which would allow of Mr. Tate's proposals being adopted, either by making use of the restricted workings, places driven through a fault, or by working in panels.

Mr. W. C. BLACKETT said that if an explosion spread through a mine and left some districts still and quiet, so as not to affect the workmen, they would not know that anything serious had occurred. Mr. Tate himself had recognized this fact in his paper. Something had occurred perhaps which was only sufficient to excite their curiosity, they were the least alarmed people in the pit, but thinking there might be something wrong they would perhaps go outbye to see what was the matter, and if they went sufficiently far to meet the after-damp they might fall victims to it. Still, there was the fact that some people were aware of what had occurred, and were able to get to certain portions of the mine, and if in such cases they had the wit to put up the safety-doors, it was quite possible that there would be sufficient air in such districts as Mr. Tate had sketched, if a large quantity of gas were not given off by the seam, to preserve the lives of 15 or 16 men for a week. There were few seams, however, that would not give off a large quantity of some kind of gas, and this would tend to diminish the length of time, although in many cases it might run into days.

Mr. J. M. Liddell suggested the desirability of having telephonic communication from the surface to the different parts of the workings as a means of safety. This communication was desirable, so that the men in a given district might be warned of the danger which had arisen from an explosion in another district, and that when it was discovered they might be prevented from becoming struck with panic, and running into the after-damp. If telephonic communication could be made it would have a reassuring effect, and it would be possible to warn the men in all districts before the after-damp reached them, and to give them proper instructions. There was perhaps some little difficulty with regard to the question of carrying the wires so as to avoid breakage, in case of an explosion, but he thought that this difficulty might be overcome.

Mr. C. J. Murton said he foresaw a difficulty in not being able to ascertain with certainty the part of the mine affected by the explosion. If the wrong doors were closed men might be imprisoned who were really not otherwise in danger.

Mr. Joseph Routledge said that in his younger days he had been down the mine during two explosions, and he had found that wherever an explosion took place the force came back into the place it had left. The explosion took place, went as far as the force would allow, and this was followed by a movement or "back-lash" towards the place of origin.

The President said that every means should be adopted even to save a single life. At present he could not say more than that it was most desirable that means should be adopted by which lives might be saved by the intelligence of the people working in the district.

Mr. Simon Tate said that if an explosion occurred and reached a given district, it was not much use trying to save the men there afterwards, as they would probably all be killed. He thought there were very few pits that had not new districts where the system could be adopted, but he agreed that it would be difficult to apply it to the case of broken or pillar workings, unless there were troubles or faults which isolated a portion of them. One speaker remarked that men rushed out at the first alarm and were lost, but his (Mr. Tate's) experience was that very few did that. In three different explosions that he had known, 13, 26, and 30 men, respectively, came so far out and met the fumes, and then went back to try and escape by the return air-ways. Workmen were found in the return air-ways who had tried to get out in various ways. They only wanted to know how to isolate themselves, and they would have done it, they had not lost their self-control. In one case, as soon as they heard the sound of the explosion 3 rushed out, but 13 workmen remained until

they got the deputy to lead them, and by that time the air had taken another course, cleared a portion of the district, and they got safe to the shaft.

Mr. A. L. Steavenson asked whether Mr. Tate had applied his suggestions practically ?

Mr. Tate said that he had not, but he had not put his opinions on paper without due consideration, and he thought it better to bring the matter forward at once rather than wait for an explosion.

The President proposed a vote of thanks to Mr. Tate for his paper, which was agreed to, and the discussion was then adjourned.

The following paper by Mr. E. P. Wood on the "British Guiana Gold-fields" was then taken as read :—

BRITISH GUIANA GOLD-FIELDS.

By E. P. WOOD, Commissioner of Mines.

So little is known of the whereabouts of British Guiana that perhaps the writer may explain that it lies on the northern coast of South America, and not on the West Coast of Africa, as so many people think.

British Guiana is readily reached from Southamption by one of the Royal Mail line of steamers; in about twelve days the traveller arrives at Barbados, where he transhipps into a smaller steamer, and thirty-six hours later he lands at Georgetown, the capital town of British Guiana (or Demerara as it used to be called).

The best time of the year to arrive in British Guiana is about October; but with the exception of July, August, and September, there is very little difference in the climate all the year round.

A large area of the coastland is occupied by sugar-planters, and the gold-regions are found some distance inland.

The climate resembles that of Northern Queensland, being too hot for hard manual work by Europeans, but not too hot for prospecting or for superintending the work afterwards. The heat in the shade seldom exceeds 90 degs., but it is a very exhausting heat, and equal, in the writer's opinion, to 120 degs. in other countries. There are two wet seasons in the year, for two months each, about Christmas and Midsummer. The rainfall may be taken at about 110 inches a year.

Gold is being found in British Guiana up the several rivers at a distance of from 100 miles to 300 miles from Georgetown. The richest district is upon the Potaro river, a branch of the Essequebo. In the North-west district, gold is being obtained from the Cuyuni, Mazaruni, and Demerara rivers. The return from the various districts during the last two years for placer-washing, was :—

Districts.	1892-93. Ounces.	Dwts.	Grs.	1893-94. Ounces.	Dwts.	Grs.
Essequebo	68,033	6	8	72,287	7	10
North-west	32,905	1	8	31,837	17	11
Cuyuni	20,712	1	8	24,978	0	1
Mazaruni	12,216	5	3	9,418	17	2
Demerara	257	13	20	5	14	14
Totals	134,124	7	23	138,527	16	14

The following statement shows the amount of gold obtained in the colony during the below-mentioned years:—

Years.	Gold. Ounces.	Dwts.	Grs.	Years.	Gold. Ounces.	Dwts.	Grs.
1884	250	0	0	1889-90 ...	32,332	16	5
1885	939	0	0	1890-91 ...	66,864	4	21
1886	6,518	1	12	1891-92 ...	110,555	12	5
1887	10,986	14	0	1892-93 ...	134,124	7	23
1888-89 ...	20,216	1	8	1893-94 ...	138,527	16	14

The exports of gold, and its declared value, during the years ending March 31st, 1892-93 and 1893-94 were as follows:—

Years.	Gold Exported. Ounces.	Dwts.	Grs.	Values. Dollars.	Cents.
1893-94	137,629	2	18 ...	2,451,408	01
1892-93	133,146	14	4 ...	2,366,100	51
Increase	4,482	8	14 ...	85,307	50

The country is all dense forest-land; and, as no roads have been formed, the only way of getting to the different places is by boat, the rivers all being navigable for great distances inland. People going gold-digging either buy or hire a boat sufficiently large to carry, say, twelve or fourteen workmen and three months' provisions. They then engage and register a certain number of labourers. There are steamers leaving once a week for the North-west district, and every day for Bartica, a settlement at the junction of the three rivers—Cuyuni, Mazaruni, and Essequebo. Thence you have to take to your boat and paddle to your destination. Flooded rivers do not stop the boats from going up, except on very rare occasions.

The connexion of the Demerara river with the Essequebo above the falls by the Demerara-Essequebo Railway, will avoid the danger of boat accidents and the difficulty of passing the rapids of the Essequebo river. It is important that this line of railway should be completed with as little delay as possible, and when it is finished the gold-output from this district of the colony will be considerably increased.

All food, tools, etc., can be obtained in Georgetown at reasonable rates. Boats cost about £25 each. A labourer's wage is 2s. 8d. per day and his food costs about 10d. per day.

The royalty on all gold obtained in the colony is 3s. 9d. per ounce, and must be paid to the Colonial Treasury at Georgetown before the gold can be sold.

A prospecting licence costs 2s. 1d. per month; for every grant of a mining claim 8s. 4d. per month, and for every grant of a placer claim 4s. 2d. per month.

The area of each alluvial working claim is 1,500 by 500 feet, and as a rule the depth of stripping is about 4 feet and the wash about 2 feet thick. The claims are all heavily timbered. Water is fairly plentiful, but has very little fall, as the country is somewhat flat. In many claims pumps might be used, instead of bailing with buckets as at present.

In one or two instances rich placer-claims have been re-worked with profitable results.

Reef-claims are not being worked at present, but the Kanaimapoo Company has erected crushing machinery. The quartz is very rich, many surface samples assaying 50 ounces per ton; and though these may have been selected pieces, yet, where there is no visible gold, it often yields 8 to 10 ounces per ton. The reefs are of all sorts and sizes, the quartz being very friable, but so little has been done as yet that one cannot form a very correct judgment as to their permanency. There may be an exceedingly rich reefing district, but the chief thing needed is workmen that understand mining. The labourers require to be educated in underground work, but there is no reason why they should not make good miners eventually.

During the past 12 months, several parties have been prospecting for and locating mining claims. The writer believes that the future success of the colony as a gold-producing country will be dependent upon quartz-mining rather than upon the working of placer-deposits.

The number of claims located during the years 1892-93 and 1893-94 has been as follows:—

	1892-93.	1893-94.
Placer	1,122 ...	1,425
Mining	48 ...	751

During the years 1893-94 3,333 prospecting licences were issued, and 105 second authorities were given out as licences.

Timber for mining purposes grows on every claim, and each claim-holder is entitled to cut what he requires free. If more is required than his claim can yield, a wood-cutting grant can be obtained at a small rental.

At present there are very few white men working, nearly all the exploring parties being composed of blacks, financed by store-keepers and others in Georgetown. This mode of working must very shortly cease, as the gold in many cases does not find its way to the owners.

A few white miners are now coming into the colony and appear to be able to stand the climate, but unless they come in larger numbers there can be no material increase in the production of gold.

The labourers are African blacks, the descendants of the slaves of former years. But their labour cannot be properly applied without the superintendence of white miners. The following statement shows the number of gold-mining labourers registered monthly during the year 1893-94 :—

1893.	Baramanni.	Bartica.	Georgetown.	Koriabo.	Totals.
April ...	—	317	968	—	1,285
May ...	48	370	917	158	1,493
June ...	43	676	858	153	1,730
July ...	52	555	1,132	360	2,099
August	46	1,046	1,547	73	2,712
September	61	449	975	279	1,764
October	62	278	661	127	1,128
November	36	297	514	139	986
December	33	85	220	102	440
1894.					
January	4	1,281	1,520	204	3,009
February	181	438	632	306	1,557
March...	83	415	602	168	1,268
Totals	649	6,207	10,546	2,069	19,471

It must, however, be noted that in many cases labourers have registered themselves several times during the year, so that the figures recorded in the preceding table are somewhat higher than the actual number of workmen employed.

The number of gold-mining labourers registered during a few recent years is as follows :—

Years.	No. of Workmen.	Years.	No. of Workmen.
1888-89	4,765	1891-92	22,298
1889-90	7,224	1892-93	22,957
1890-91	15,622	1893-94	19,471

There was a decrease of 3,486 in the number of gold-mining labourers registered during 1893-94, as compared with 1892-93, but this decrease may be accounted for by the fact that fewer people are embarking in the gold industry, owing to the dishonesty that is practised at the diggings.

The value of gold produced per labourer during the last two years was as follow :—

Years.	No. of Workmen Registered.	Value of Gold Produced. Dollars.	Cents.	Average per Workman. Dollars.	Cents.
1892-93	22,957	2,414,239	16	105	16
1893-94	19,471	2,493,500	93	122	92

Every day proves that British Guiana is an extraordinarily rich country, and that it simply requires development by capital.

It may be asked how it is that the production of gold has not increased at a greater rate than it has, but the answer to that question is: that the number of workmen was less last year than it was the year before.

There is not the slightest doubt that in years to come there will be a very large output of gold from British Guiana.

Copper and silver have been found in the colony, but there is nothing as yet to prove that they exist in payable quantities.

Several diamonds have been found in panning-off the gold at the end of a day's work, and, considering that they are found under such circumstances, a diamond miner would be of opinion that they must exist in larger quantities. The writer has no doubt that diamond mining would pay, if a small pulsating-machine were tried. There is little chance of a diamond stopping in the box in sluicing, and still less chance of its being discovered in panning-off. Many of the labourers employed, never having seen a diamond in its natural state, are only attracted to it by the peculiarity of its shape.

Mr. Bennett H. Brough regretted that the author had not given some historical information, so as to render his valuable paper thoroughly complete. Few countries presented greater historical interest. From the time of the discovery of Guiana, four hundred years ago, the imaginations of the Spanish settlers were fired by the accounts given by the Indians of the abundance of gold in the interior. Many expeditions were fitted out to seek for these gold deposits, the best known being that of Sir Walter Raleigh, who started in 1595 in search of "Manoa, the imperial city of Guiana, which the Spaniards call El Dorado." On his return he published an account of his adventures, a fascinating volume, bearing a strong family resemblance to the mine prospectuses of modern times. Much money and many lives were expended in this expedition, and the existence of gold in Guiana has since invariably been regarded with incredulity. It was thought to be an accompaniment of an age of romance, and one frequently came across allusions to "the El Dorado myth." The startling figures given by Mr. Wood, showing the rapid annual increase in the gold production from 250 ounces in 1884 to 138,527 ounces in 1893-94 undoubtedly proved, however, the accuracy of Sir Walter Raleigh's belief in the gold resources of Guiana. Sir Walter Raleigh brought back with him specimens of ore, some of which was, he

said, "as rich as the earth yieldeth any." He was, however, not able to conduct any mining operations, his explanation being as follows:—

We were not able to tarry and search the hills, so we had neither pioneers, bars, sledges, nor wedges of iron, to break the ground, without which there is no working in mines: but we saw all over the hills with stones of the colour of gold and silver, and we tried them to be no marquesite, and therefore such as the Spaniards call El Madre del Oro, which is an undoubted assurance of the general abundance; and myself saw the outside of many mines of the white spar, which I know to be the same that all covet in this world.

Sir Walter Raleigh, it thus appeared, was aware of the existence of quartz reefs. The workings of his date appeared, however, to be alluvial. His description was as follows:—

I after asked the manner how the Epuremei wrought these plates of gold, and how they could melt it out of the stone; he told me that most of the gold which they made in plates and images was not severed from the stone, but that on the lake of Manoa, and in a multitude of other rivers, they gathered it in grains of perfect gold, and in pieces as big as small stones, and that they put to it a part of copper, otherwise they could not work it, and that they used a great earthen pot with holes round about it, and when they had mingled the gold and copper together, they fastened canes to the holes, and so with the breath of men they increased the fire until the metal ran, and then they cast it into moulds of stone and clay, and so make those plates and images.

The meeting was then closed.

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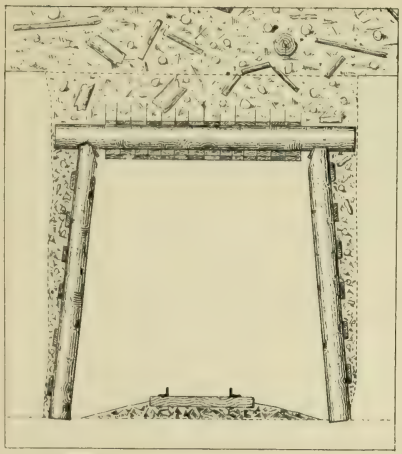

Fig. 3. Cross Section.

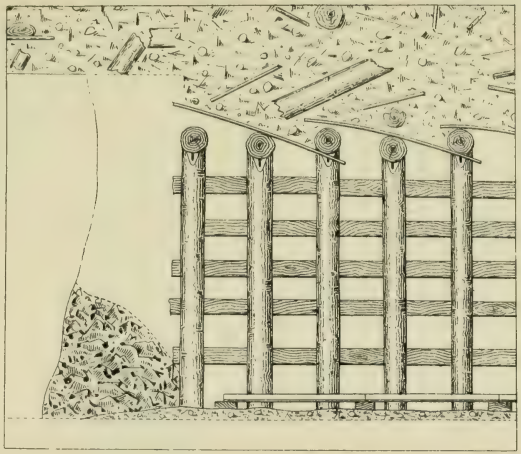

Fig. 4. Longitudinal Section.

Scale - 4 Feet to 1 Inch

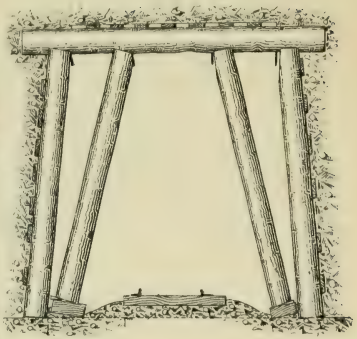

Fig. 5.

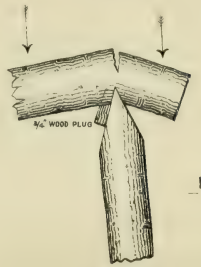

Fig. 6.

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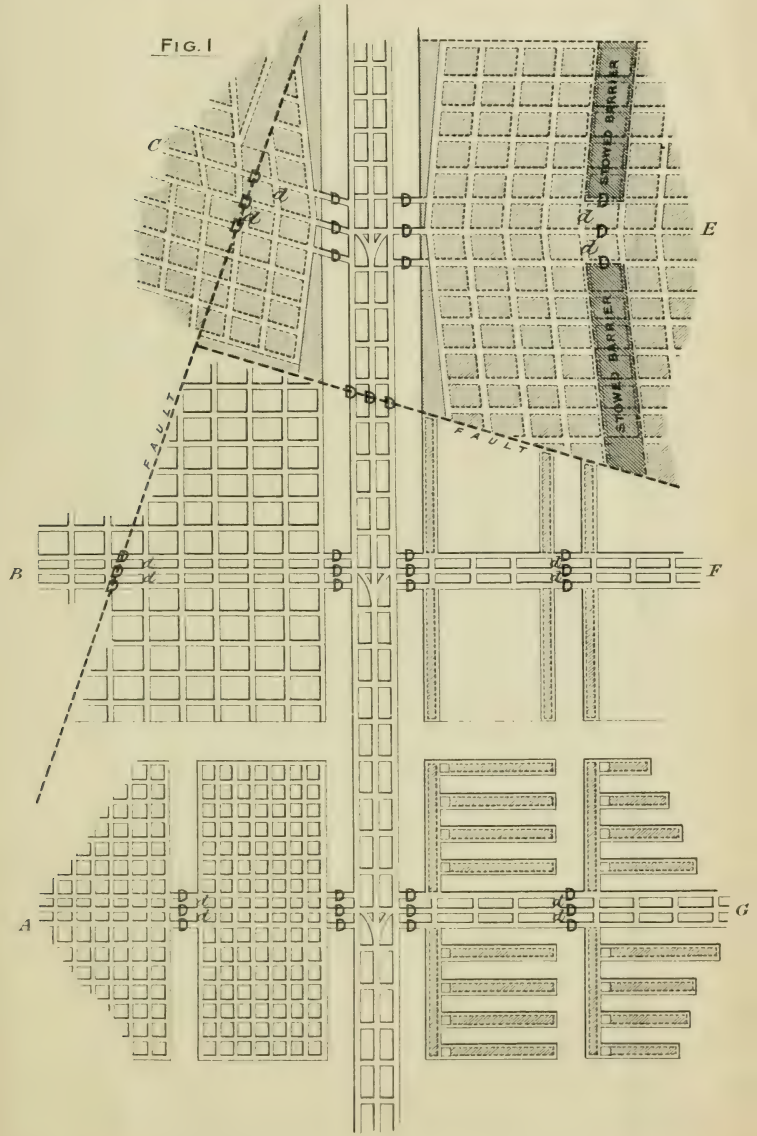
Federated Institution of Mining Engineers.
Transactions 1894.

To illustrate Mr. S. Tate's Paper on "Saving of Life from After-damp, Smoke or Fumes in Mines."

FIG. 1



Trans. Federated Institute of Mining Engineers
And.w Reid & Comp.y Ltd. Newcastle upon Tyne
Vol. XLIV Plate XII.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

NOVEMBER 24TH, 1894.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous General Meeting and reported the proceedings of the Council of that day.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Mr. WILLIAM GARNETT, M.A., D.C.L., 13, Spring Gardens, London, S.W.

MEMBERS—

Mr. B. ANGWIN, Mining Engineer, P.O. Box 231, Johannesburg, Transvaal.

Mr. GEORGE BELLINGHAM, Licensed Land and Mining Surveyor, Coolgardie, Western Australia.

Mr. ALFRED HAMMOND BROMLY, Mining and Mechanical Engineer, Llannwchllyn, near Bala, North Wales.

Mr. RONALD C. CAMPBELL-JOHNSTON, Metallurgist, Assayer, and Mining Engineer, P.O. Box 40, Vancouver, British Columbia.

Mr. HENRY REYNOLDS CHAPMAN, Mechanical Engineer, Victoria Works, Gateshead-upon-Tyne.

Mr. ROBERT EDDEN COMMANS, Mining Engineer, 6, Queen Street Place, London, E.C.

Mr. RICHARD STAFFORD COUSINS, Civil Engineer, Coach Road House, Whitehaven.

Mr. ROBERT FOWLER, Colliery Manager, Washington Colliery, Washington Station, R.S.O.

Mr. HENRY RICHARD HANCOCK, Superintendent, Wallaroo and Moonta Mines, Moonta Mines, South Australia.

Mr. REIJI KANDA. Mining Engineer, c/o Mr. Takahira Kanda, 9, Awajicho-Nechome, Kanda, Tokio, Japan.

Mr. HEINRICH WILHELM FERDINAND KAYSER, Mining Manager, The Mount Bischoff Tin Mining Co., Waratah, Tasmania.

Mr. WILLIAM LECK, H.M. Inspector of Mines, Cleator Moor, Cumberland.

Mr. DUNCAN MCGEACHIE, Manager, Waratah Colliery, Charlestown, near Newcastle, New South Wales.

Mr. D. H. F. MATTHEWS, H.M. Inspector of Mines, Newton-le-Willows.

Mr. James Jones Meldrum, Manufacturing Engineer, Atlantic Works, City Road, Manchester.

Mr. Septimus Oliver, Mining Engineer, Tyne House, Tynemouth.

Mr. Frederick Danvers Power, Mining Engineer and Metallurgist, c/o Messrs. Henderson & Macfarlane, 2, Bridge Street, Sydney, New South Wales.

Mr. William Edward Sam, Jun., Mining Engineer, c/o Messrs. F. & A. Swanzy, Cape Coast Castle, Gold Coast.

Mr. Harry Sladden, Mining Engineer, Chorlton Chambers, P.O. Box 1666, Johannesburg, Transvaal.

Mr. George Paton Walsh, Engineer, 138, Reguliersgracht, Amsterdam, Holland.

Mr. Horace V. Winchell, Geologist and Mining Expert, 316, Tenth Avenue, S.E., Minneapolis, Minn., U.S.A.

Associate Members—

Mr. Alfred Molyneux Palmer, Coal Owner, 14, Windsor Terrace, Newcastle-upon-Tyne.

Mr. Sydney C. Rudman, Land Agent and Engincering Surveyor, Estate Office, Windlestone, Ferryhill.

Mr. Robert Sheard, Engineer and Boiler Builder, Caldervale Boiler Works, Wakefield.

Mr. G. Young Wall, Manorial Surveyor and Local Deputy Steward to the Ecclesiastical Commissioners for England, Halmote Court Office, New Exchequer Buildings, Durham.

Associates—

Mr. Arthur Morton Hedley, Assistant Overman, Barrow Collieries, Barnsley.

Mr. James Stokoe, Overman, Murton Colliery, *via* Sunderland.

Students—

Mr. John Henry Bacon Forster, Mining Student, Hetton Colliery, Hetton-le-Hole, R.S.O.

Mr. Nathaniel Maurice Griffith, Mining Student, c/o Broughton & Plas Power Coal Co., Limited., Wrexham.

Mr. Tom Alfred Lishman, Mining Student, The Tower, Durham.

Mr. Albert Littlejohn, Mining Student, Ashington Colliery Offices, Morpeth.

Mr. Philip Neasham, Mining Apprentice, Colliery Office, Medomsley, Co. Durham.

Mr. Norman Nisbet, Mining Apprentice, Tantobie, Co. Durham.

The following gentlemen were nominated for election :—

Members—

Mr. G. A. Denny, Mining Engineer, Farm Tusschenby, Denny Dalton Gold Fields, Vryheid District, Transvaal.

Mr. Thomas Gilbert Dobb, Mining Engineer, Derby Terrace, Hindley, near Wigan, Lancashire.

Mr. Edgar Tom Gardiner, Mechanical Engineer, 8, South View Terrace, Bishop Auckland.

Prof. EDWARD HULL, Consulting Geologist, 20, Arundel Gardens, London, W.; and 4, Fenchurch Avenue, London, E.C.

Mr. JOHN MURRAY, General Manager, Raneegunge Coal Association, Limited, Giridih, India.

Mr. ALEXANDER ROSS, Manager, Wallsend Colliery, Newcastle, New South Wales.

Mr. FREDERICK AUGUSTUS THOMPSON, Mining Engineer, Broad Street House, London, E.C.

ASSOCIATE MEMBERS—

Mr. JAMES DODDS, Pearson and Knowles' Coal and Iron Company, Limited, Dallam and Bewsey Forges, Warrington.

Mr. F. GILLMAN, Gartenstrasse 1, Freiburg, Baden, Germany.

Mr. GEORGE ERNEST GREGSON, Land Agent, and Land and Mine Surveyor, 11, Chapel Street, Preston.

Mr. CHARLES ALBERT SMITH, Ropemakers' Representative, 20, Alexandra Place, Newcastle-upon-Tyne.

ASSOCIATES—

Mr. GEORGE ELTRINGHAM, Master Shifter, Shiremoor Colliery, Newcastle-upon-Tyne.

Mr. JOHN HARRISON, Under-manager, Ashington Colliery, Northumberland.

Mr. ROBERT LINDAY, Colliery Surveyor, Bishop Auckland.

Mr. JOHN HENRY MILLER, Colliery Surveyor, South Hetton, Sunderland.

STUDENTS—

Mr. WALTER NEWTON DREW, Articled Pupil, Thorncliffe Collieries, near Sheffield.

Mr. WILLIAM DENHAM HARBIT, Mining Student, 32, High Street, Wallsend.

Mr. JOSEPH HENRY SHERWEN, Mining Student, Marina Terrace, Hensingham, Whitehaven.

DISCUSSION ON THE "REPORT OF THE PROCEEDINGS OF THE FLAMELESS EXPLOSIVES COMMITTEE. PART I.—AIR AND COMBUSTIBLE GASES."

Mr. A. C. KAYLL read the "Report of the Proceedings of the Flameless Explosives Committee. Part I.—Air and Combustible Gases."

The PRESIDENT hoped that the enquiry would bring about some important results, and that they would be assured as to whether they could with safety use high explosives in coal-mining operations.

Mr. A. L. STEAVENSON said that the subject was a very difficult one to deal with, and he had no desire to find fault with the valuable report of the Committee. They were told in the report, the claim had been made for flameless explosives "that when exploded the temperature of the gaseous products was so low that they were incapable of igniting fire-damp

or coal-dust, and that such explosives were safe for general use in mines."* Whether this was claimed for high explosives or not, he did not think it was correct; his impression was that the temperatures produced by high explosives were extremely high and intense, and that blasting-powder produced a much lower temperature of a more protracted nature in its explosion. In that respect it was more dangerous, because pellets of the powder were thrown out by a blown-out shot and passed down the gallery in a state of ignition. He had on previous occasions referred to a case coming within his own knowledge in which blasting-powder had been blown a distance of 40 or 50 feet, burning a workman who was sitting without his shirt. The markings of the pellets on a tub were easily observed. It was further stated that the enquiry was "instituted with the object of clearing away the doubts and uncertainties connected with the employment of safety explosives in mines."† He would like to have seen blasting-powder tested in the same way; probably the results would have been disastrous to the reputation of powder, but it would have been interesting to have had the results recorded. They were also told of the means adopted by Messrs. Bedson and Shaw for testing the strength of the different explosives, and a little drawing was given on the plan (Fig. 10, Plate I.), but he thought that this did not give quite sufficient information as to what the process was.‡ He presumed that after the explosion of a charge in the leaden cube, the volume or space was measured by means of water, and thereby one arrived at a comparison of the relative strengths of the explosives.§ The general tenor of the report seemed to point very distinctly to the safety of carbonite, and it seemed pretty clear that in all the experiments carbonite had done excellently. He suggested that there should be a few more tests made with carbonite, for if it were true that carbonite was safer than the other explosives it was desirable that this should be made clearly known. It was stated that experiments were not made with stemmed shots fired into air only for the purpose of observing the presence of flame,‖ but if the Committee had time he thought it was desirable that they should make further experiments on this point alone. It might not alter the results obtained in the recorded experiments, but it would form concurrent testimony of their value. It was stated that all high explosives were less likely to ignite gaseous mixtures than blasting powder, but this was without proof, and he suggested that further experiments should be made with powder to decide that question.

* *Report*, page 3. † *Ibid.*, page 5. ‡ *Ibid.*, page 16. § *Ibid.*, Table I., page 17. ‖ *Ibid.*, page 24.

Mr. Henry Hall (H.M. Inspector of Mines) said that the Institute was to be congratulated on having undertaken these valuable experiments, and on having brought them so far to a successful issue; and more especially were the gentlemen to be congratulated who had conducted the experiments and devised the necessary appliances for carrying them out so successfully. It appeared to him that all the high explosives which had been tested, either stemmed or unstemmed, were capable of igniting explosive mixtures of coal-gas and air, but in the case of explosive mixtures of pit-gas and air—and they had to draw a distinction between pit-gas and coal-gas—when unstemmed, some of them ignited the gaseous mixtures and some did not; when fired in the usual way with stemming, none of the explosives ignited the mixture of pit-gas and air. They were led to suppose that this came about from the fact that there was a difference in the temperature necessary to ignite coal-gas and air and pit-gas and air, and that that difference only amounted to something like 34 degs. Fahr. It took about 1,232 degs. Fahr. to ignite pit-gas and air, and 1,198 degs. Fahr., or about 34 degs. less, to ignite coal-gas and air, so that the whole of the safety of high explosives depended apparently on this small difference of temperature.* This difference seemed a very slender thread to depend upon, and he himself thought that it might possibly disappear altogether under certain circumstances. For instance, he thought it very likely that certain kinds of pit-gas would explode at different temperatures, and that they might have a slow gas and a quick one. The gas with which these experiments were tried came, he believed, direct from blowers in the mine, but possibly it was not as quick as another gas might be, which issued freshly from the working-face of another mine. They all knew that there was a great deal of difference in the behaviour of gases underground; some, when ignited, showed a long cap, and some a short cap. He himself had ignited pit-gas with a red hot poker, but they might seek a pit through before they would find gas which they could ignite again in that manner; still, very inflammable gas did sometimes appear in pits and that which appeared from freshly-cut coal-faces might be more readily ignited than gas which had been merely pent up or derived from blowers in a coal-mine. Questions also arose which might do away to some extent with safety, such as the bulk of the flame brought in contact with the explosive mixture. In these experiments, very small charges of explosive were used; possibly if larger charges had been used—charges such as would be used underground in firing shots—some of the

* *Report*, page 36.

results might have been different, for he believed it was admitted that even flame of a fixed temperature if applied in large volume would sometimes ignite a gaseous mixture which a small volume would not ignite. He thought it most desirable that in future, experiments on this point should be taken into consideration, and that instead of dealing with an ounce of the explosive they should deal with the usual charges used underground. In addition to the danger of igniting mixtures of fire-damp and air underground with explosives, there was also the danger of igniting coal-dust; and it would almost seem from experiments which had been carried out, that coal-dust could be more readily ignited than mixtures of fire-damp and air. Possibly that arose from the fact that coal-dust was ignited by bringing it into contact with a flame which had the effect of heating it, and so distilling gas from the coal; the gas thus distilled was not fire-damp, but more nearly approached lighting-gas or coal-gas, which could be lighted by a flame of lower temperature, so that possibly dust might be ignited by an explosive which would not ignite gas and air. Recent experiments at Wigan showed that nearly all high explosives when fired in charges of one pound without any stemming, ignited coal-dust, gas being absent. Ardeer powder, carbonite, and westphalite were, however, exceptions. But although the experiments made by the Committee had shaken their confidence in the safety of high explosives, he thought there could be no question that these were very much safer than the old-fashioned explosives. He thought this safety was more especially due to two causes: first, that high explosives were not nearly so liable to produce blown-out shots, which were the real cause of the danger; and, second, that the ignition of fire-damp mixtures did not depend so much upon the temperature of the flame as upon the rapidity and the instantaneousness of the production of the flame. He agreed with Mr. A. L. Steavenson that the temperature of these safety explosives was very high; much higher than was necessary to inflame coal-gas and air or pit-gas and air. There was one point he would like the Committee to take into consideration, if possible, in future experiments—and if the future experiments became very expensive, he had no doubt the matter would be considered of such public importance that they might obtain funds from H.M. Treasury to assist in carrying them out—and that was in regard to the amount of force developed by explosive mixtures of fire-damp and air. He had always felt that mining engineers were very much in doubt upon this point, and now that they had this expensive apparatus, he thought the question might be solved. He thought the mining profession, as a rule, had no definite information upon the question as to what damage a small amount of gas might do.

Mr. M. Walton Brown said that the Committee had not been able to obtain a sufficient supply of westphalite for the purpose of the experiments. The makers had been asked to send a supply, but the request had not been acceded to.

Mr. C. C. Leach asked Mr. Hall to give a description of the cannon which had been used in the experiments in which charges of one pound of explosive were used ?

Mr. H. Hall said that the cannon had proved of sufficient strength to withstand the effects of the explosives when fired untamped. He understood that the cannon had cost about £120.

Mr. M. Walton Brown said that he had assisted Mr. W. Foggin in making a large number of experiments with charges very much lighter than those mentioned by Mr. Hall, with the result that two cannons were destroyed, and the danger of the experiments would have been greatly enhanced if the weight of the explosive had been increased. The temperature of the ignition of fire-damp was about 1,200 degs. Fahr., but it was necessary that the effects of such a temperature should be prolonged for some time in order that the mixture might be ignited. The experiments of the French Commission showed that the retardation of ignition characteristic of fire-damp mixtures, the almost instantaneous mixture of the gases resulting from the ignition of the explosive with the surrounding air, and the quick cooling consequent thereon, combine to make explosives whose temperature of detonation is less than 4,000 degs. Fahr. incapable of igniting explosive mixtures of fire-damp and air, under normal conditions of use; that is to say, in holes and properly stemmed. A further point in the use of explosives seemed to be the fact that the safety of their ignition in an explosive gaseous mixture depended upon the almost instantaneous mixture of the gases produced by the detonation of an explosive with a sufficient volume of surrounding air. It was highly probable that it might be dangerous to fire a shot in a too limited space and with a weight of explosive too great for the volume of the surrounding air as compared with the volume of the gases produced by the detonation. Perhaps Dr. Bedson would give them some information as to the temperature of ignition of pit-gas and coal-gas alone and in mixtures with air. In the "Report of the French Commission on the Use of Explosives in the Presence of Fire-damp in Mines," it was stated that "the apparent temperature of ignition of a mixture of air and gas and coal-gas containing 10 per cent. of this gas, would, therefore, be about 3,812 degs. Fahr. With mixtures of air and fire-damp,

the temperature was found to be about 3,992 degs. Fahr."* Messrs. V. Meyer and Münch state that marsh-gas ignited at 1,232 degs. Fahr., and coal-gas at a temperature of 1,198 degs. Fahr. It seemed to him (Mr. Brown) that some attempt might be made to reconcile this difference of something like 2,700 degs. It might be that the difference was due to Messrs. Meyer and Münch's experiments being made with marsh-gas and coal-gas and oxygen, and not with marsh-gas and coal-gas and air.

Dr. P. P. Bedson said with regard to the difference in temperature of ignition coal-gas and air and marsh-gas and air as given by the French Commission and as observed in the experiments of Messrs. Meyer and Freyer and by Messrs. Meyer and Münch, that the latter experiments were quoted in the report now under discussion as being the most recent results on the subject. Prof. Meyer had used oxygen and not air in his experiments, but that would not make the difference which Mr. Brown had brought out by quoting the results of the French Commission. He thought they might accept the results obtained by Prof. Meyer in his experiments as reliable, because that gentleman had paid very considerable attention to this matter, and had used in the measurements of temperature some of the most recent and most perfect devices for recording temperatures. He (Dr. Bedson) would be therefore inclined to accept his results as conclusive and as material upon which to base their conclusions. Mr. Hall had referred to the varieties of pit-gas, and from what they knew of the gases occluded by coal and enclosed in coal-dust they would no doubt be ready to admit that a difference must exist in the gases met with in coal-mines. One would expect that fire-damp from some mines would contain not only marsh-gas but some of the higher members of the series to which marsh-gas belonged, and other specimens of fire-damp would no doubt be found which contained hydrogen. In the Wigan district a gas was met with, known as "sharp gas," which he thought contained not only marsh-gas but a considerable percentage of olefiant gas. The mode of measuring the force of explosives in the leaden cube was as follows:—The volume of the cavity created by the force of the explosion was measured by means of water. He might add that in estimating the value of any explosive it was necessary to take into consideration the safety of the fumes which the explosive might produce on detonation, and it had been ably demonstrated by Mr. Orsman† that carbonite developed a considerable quantity of combustible gases, which would make the use of carbonite a source of considerable danger, requiring special ventilation for the removal of the carbon monoxide and other gases so produced.

* Page 76. † *Trans. Fed. Inst.*, vol. iii., page 94.

Mr. J. L. Hedley (H.M. Inspector of Mines) hoped that the paper would be very thoroughly examined and criticized. It should, however, be remembered that the Committee had only given absolute facts, with the exception of the pages which contained the conclusions which had been derived from the facts. With reference to Mr. Steavenson's suggestions as to experiments with gunpowder in gaseous mixtures, he might point out that throughout the experiments the mixtures had been tested at intervals with gunpowder and always with the same result, namely, that if there was an explosive mixture of air and gas an explosion was produced. If the mixture was not explosive, they merely got an elongation of the flame of the shot: the results were invariably the same, and the effects so plain that the Committee had not thought it necessary to include them in their report. This remark applied to both pit-gas and coal-gas. He was glad that Mr. Hall had spoken as he had of the possibility of obtaining assistance from public funds. The experiments conducted by this Institute were of the greatest possible importance, and it could not be expected that the members would devote their time and money year after year to them, but possibly some arrangement might be made by which the experimental station might be used in determining by practical experiments questions which might arise from time to time. The smallness of the charge of explosives was decided upon owing to the size of the cannon and the size of the bore. Had the charge been heavier, it would have been brought too near to what he might term the mouth of the shot-hole. Farther, if ignition of a gaseous mixture was produced by means of a small charge of explosive, they might reasonably conclude that they would also produce ignition with larger charges.

Mr. H. Bigg-Wither (Wigan) wrote that the last conclusion* was open to criticism, chiefly because it did not specify whether the missed charge of high explosive still contained the detonator. He (Mr. Bigg-Wither) could well imagine that it might be possible to detonate a high explosive containing nitro-glycerine by the method named, even if it did not contain a detonator; but under the same conditions a nitrate-of-ammonia explosive could certainly not be detonated. He very much doubted whether it could be taken as a certainty that even a detonator embedded in a nitrate-of-ammonia explosive would always be exploded by another charge with 8 inches of stemming intervening. He considered that this conclusion should be made a little more definite.

Mr. George Benekė (London) wrote that he had read with the

* *Report*, page 41.

keenest interest the report of the Flameless Explosives Committee, and congratulated the members on the care with which these experiments had been carried out in the public interest. He felt it his duty, however, to point out that, in his opinion, a grave error had been committed with regard to the weights of the various explosives employed. His experience was, that most of the explosives, such as roburite, bellite, ammonite, and securite, were tolerably safe when fired in charges weighing from $3\frac{1}{2}$ to 4 ounces, with No. 6 or No. 7 detonators, when untamped, in inflammable mixtures of gas and air or coal-dust. Beyond 4 ounces, the charges nearly always ignited and exploded suspended coal-dust, or an inflammable mixture of air, gas, and coal-dust. He was forced, therefore, to the conclusion that the small charges of 1 to $1\frac{1}{4}$ ounces of explosives, which the Committee exploded with No. 6 detonators, were wholly insufficient to quench the flame produced by the discharge of the detonator, and only assisted in blowing that flame into the inflammable mixture, and so producing the frequent ignitions recorded. Very recently he had erected an experimental apparatus near Wigan, where explosive charges, weighing from 5 to 16 ounces—being the average weights of charges used in collieries—could be tested in the presence of an inflammable mixture of gas and air, or air, gas, and coal-dust. In addition, a steel cannon had been fixed, by means of which the actual strength of an explosive could be ascertained.

Mr. G. B. Forster (Newcastle-upon-Tyne) said that this was perhaps the most important committee which the Institute had appointed. They had appointed many committees, and had no doubt derived a great deal of benefit and knowledge from their reports, but he thought the members would agree with him that this was the most important work which the Institute had ever undertaken. It was especially important to this district, where hard coal was so often found, that they should have accurate knowledge as to the safety of the different explosives. No doubt, when the farther report of the Committee is issued, the members will be farther enlightened as to the nature of the different explosives and their effects on various mixtures of gas, coal-dust, etc. He had pleasure in proposing a hearty vote of thanks to the Committee for the indefatigable industry and intelligence with which they had, at great inconvenience to themselves, devoted their time and attention to this subject.

Mr. J. B. Simpson, in seconding the proposal, said that, as a Mining Institute, they ought to do all that could be done to farther the extension of the experiments, and to endeavour to obtain help from H.M. Treasury or the County Councils if possible.

The PRESIDENT, in putting the motion to the meeting, said that the importance of the subject afforded sufficient ground for appealing for funds to H.M. Treasury or to the County Councils.

The vote of thanks was carried with acclamation.

Mr. J. L. HEDLEY acknowledged the vote of thanks in the absence of the Chairman of the Committee. He said that the Committee had completed a farther series of experiments with air and coal-dust alone, and hoped shortly to present a preliminary report thereon. They were now busy upon experiments with gas and coal-dust, but it must be borne in mind that only a very few experiments could be made in one day, and the members must give them credit for getting on with the work as quickly as possible. He was sure that the members of the Committee would feel gratified at the manner in which the report had been received.

Mr. A. L. STEAVENSON then moved a vote of thanks to Mr. A. C. Kayll for the skill, attention, and time that he had devoted to the work of the Committee.

The motion was seconded by the CHAIRMAN, and briefly responded to by Mr. KAYLL.

The meeting then terminated.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

DECEMBER 8TH, 1894.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council of that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. G. A. DENNY, Mining Engineer, Farm Tusschenby, Denny Dalton Gold Fields, Vryheid District, Transvaal.

Mr. THOMAS GILBERT DOBB, Mining Engineer, Derby Terrace, Hindley, near Wigan, Lancashire.

Mr. EDGAR TOM GARDINER, Mechanical Engineer, 8, South View Terrace, Bishop Auckland.

Prof. EDWARD HULL, Consulting Geologist, 20, Arundel Gardens, London, W.; and 4, Fenchurch Avenue, London, E.C.

Mr. JOHN MURRAY, General Manager, Raneegunge Coal Association, Limited, Giridih, India.

Mr. ALEXANDER ROSS, Manager, Wallsend Colliery, Newcastle, New South Wales.

Mr. FREDERICK AUGUSTUS THOMPSON, Mining Engineer, Broad Street House, London, E.C.

ASSOCIATE MEMBERS—

Mr. JAMES DODDS, Pearson and Knowles' Coal and Iron Company, Limited, Dallam and Bewsey Forges, Warrington.

Mr. F. GILLMAN, Gartenstrasse 1, Freiburg, Baden, Germany.

Mr. GEORGE ERNEST GREGSON, Land Agent, and Land and Mine Surveyor, 11, Chapel Street, Preston.

Mr. CHARLES ALBERT SMITH, Ropemakers' Representative, 20, Alexandra Place, Newcastle-upon-Tyne.

ASSOCIATES—

Mr. GEORGE ELTRINGHAM, Master Shifter, Shiremoor Colliery, Newcastle-upon-Tyne.

Mr. JOHN HARRISON, Under-manager, Ashington Colliery, Northumberland.

Mr. ROBERT LINDAY, Colliery Surveyor, Bishop Auckland.

Mr. JOHN HENRY MILLER, Colliery Surveyor, South Hetton, Sunderland.

STUDENTS—

Mr. WALTER NEWTON DREW, Articled Pupil, Thorncliffe Collieries, near Sheffield.

Mr. WILLIAM DENHAM HARBIT. Mining Student, 32, High Street, Wallsend.

Mr. JOSEPH HENRY SHERWEN, Mining Student, Marina Terrace, Hensingham, Whitehaven.

The following gentlemen were nominated for election :—

HONORARY MEMBER—

Rev. HENRY PALIN GURNEY, Principal of the Durham College of Science, Newcastle-upon-Tyne.

MEMBERS—

Mr. BASIL JOHN ATTERBURY, Mining Engineer, 18, Eldon Street, London, E.C.

Mr. WILLIAM BIBBY, Manager of the Raub Australian Gold Mining Co., Limited, Raub, Pahang, Malay Peninsula.

Mr. HARRIS BIGG-WITHER, General Manager of the Roburite Explosives Co., Limited, 10, Swinley Road, Wigan, Lancashire.

Mr. GEORGE BOOLE, Mining Engineer and Colliery Manager, Rainford, near St. Helens, Lancashire.

Mr. HENRY HUNTER CAMPBELL, Land and Mine Surveyor, and Mining Engineer, Sutton Hall, St. Helens, Lancashire.

Mr. JOHN FLINT, Colliery Manager, Broomhill Colliery, Acklington, Northumberland.

Mr. WILLIAM KENNEDY, Consulting Geologist and Engineer, Austin, Texas, United States of America.

Mr. LLOYD WILSON, Colliery Managing Director and Engineer, Flimby Colliery, Maryport.

ASSOCIATE MEMBERS—

Mr. JOHN S. BOLTON, Electrical Engineer, 78, Brighton Grove, Newcastle-upon-Tyne.

Sir GEORGE WILLIAM ELLIOT, Bart., M.P., 16, Great George Street, Westminster, London, S.W.

Mr. GEORGE B. SAUNDERS, Chemical Agent, etc., c/o Messrs. Dawson, Saunders, & Todd, Maritime Buildings, Newcastle-upon-Tyne.

STUDENTS—

Mr. HENRY DUNFORD COWAN, Mining Student, Elswick Collieries, Newcastle-upon-Tyne.

Mr. JAMES BERTRAM SAMPLE, Mining Student, South Tanfield Colliery, Stanley, R.S.O., County Durham.

Mr. THOMAS DOUGLAS delivered the following Presidential Address :—

PRESIDENTIAL ADDRESS.

By THOMAS DOUGLAS.

I appreciate and thank you for the honour which you confer upon me in electing me your President. In accepting the position and occupying the chair so ably filled by men eminent in the professions of mining and engineering who have preceded me, I can only hope to do so successfully by the aid of the Council, and by that of every member of the Institute. On this support I feel sure that I can confidently rely.

The history of the Institute has been so frequently written by Past-Presidents that I shall but very briefly refer to it. Having been connected with it from its very commencement in 1852 until the present time, I am well able to speak of the earnestness that characterized its early promoters and of the aims and hopes expressed by them in regard to it. In nowise have their expectations been disappointed. How strongly our esteemed first President, Mr. Nicholas Wood, and until his death in 1865, its continuing President, felt the necessity of such an Institution and foreshadowed its aims is well seen by the views expressed in the inaugural address delivered by him on September 3rd, 1852.

It was a valuable suggestion made at an early period, and no doubt in the mind of Mr. Wood when he gave the address referred to, that efforts should be made to amalgamate with any other institution or society of the United Kingdom, having for its object the prevention of accidents in mines.

Sir George Elliot in 1868, and Mr. John Daglish in 1886, in their Presidential addresses, and Mr. Theophilus Wood Bunning (for many years and until shortly before his death the valued secretary of our Institute), in a paper read by him in 1887, all strongly urged the desirability of such a combination; thus was brought about in 1889, a Federation, the object of which was to include all "societies interested in mining, metallurgy, engineering, and their allied industries."

The Federated Institution of Mining Engineers now comprises six institutes, with over 2,200 members, and I trust that during the present financial year other kindred societies not yet associated may be added.

The present number of Members, Associates, and Students in the North of England Institute of Mining and Mechanical Engineers is 791, showing an increase of 73 over the previous year.

I would draw special attention to the encouragement now offered by the Institute to the large class of under-viewers, under-managers, colliery engineers, students, and others who by a yearly subscription of one guinea are admitted as Associates or Students. I would impress upon every class the value and importance of taking advantage of this arrangement under which they would be entitled to consult the library, receive the *Transactions*, attend the meetings, and assist in the discussions. Already some have so joined, but the number is capable of very great extension, and members can do much towards this end by bringing the subject more prominently before the classes indicated.

I have on more than one occasion alluded to the desirability also of more distinctly urging the Institute's claims for support upon the owners of collieries and royalties. We are glad to record an increase in the number (now 22) of those who are already subscribers. We have, I think, peculiar claims upon these gentlemen. The expense incurred in carrying on the needful experiments, whereby such experience is gained as may lead to increased safety and economy in working mines, is very large, and colliery owners must be very greatly benefited thereby.

The "Explosives Committee" are now engaged in important experiments, which could not have been carried out had not the Institute received substantial aid from the Coal Trade Associations and from other bodies.

When we remember the responsibilities that attach to the position of a mining engineer, the lives that so largely depend upon his careful supervision and forethought, the depths to which shafts are now sunk, and the distance to which the ramification of the mines extend, it is obvious that men can only now occupy such positions with credit whose education and training have been of a thoroughly practical and scientific character.

Fortunately the opportunities for obtaining such instruction and experience are now materially enlarged.

Science classes have been established in every mining district—that admirable institution, the Durham College of Science, towards the establishment of which in our midst we have been much indebted to members of this Institute, has opened wide its doors to us, and its professors assist largely in our deliberations; whilst County Councils and Guilds by grants and scholarships enable deserving students, at small expense, to take advantage of the means now placed within the reach of all.

On the shelves of the library in the Wood Memorial Hall we find some 8,000 volumes, in which we may glean the information and

experience gathered up by men eminent in the profession from all parts of the world, and on every subject connected with mines and mining.

A paper, written by Prof. Merivale, which appeared in the *Transactions* of The Federated Institution of Mining Engineers,* in reference to the education of mining students, is worthy of attention by young men proposing to enter the profession.

I need not remind you that our object is, in the first place, to aim at increased safety for the lives of the army of workers engaged in or about the 3,383 mines of the United Kingdom, at which, according to the (1893) reports of the Inspectors of Mines, 683,008 persons were engaged, and from which 175,236,857 tons of minerals were extracted during the past year.

The farther information furnished in these valuable reports indicates the character of the accidents that have resulted in death.

In 1893, the deaths that occurred were 1,060.

Of this number 160 or 15·10 per cent. were caused by explosion;
412 or 38·89 „ „ falls;
103 or 9·70 „ occurred in shafts;
29 or 2·73 „ were caused by explosives or by suffocation;
131 or 12·36 „ „ tubs or on engine-planes;
105 or 9·90 „ occurred from sundry causes;†
120 or 11·32 „ „ on the surface.

During the ten years previous to 1893, the deaths averaged 1,032 per year.

Of which 147 or 11·24 per cent. were caused by explosions;
460 or 44·57 „ „ falls;
88 or 8·53 „ occurred in shafts;
231 or 22·38 „ „ from sundry causes;
106 or 10·28 „ „ on the surface.

The average death-rate, which for the ten years previous to 1883 was 2·243 per 1,000 persons employed, or 7·420 per 1,000,000 tons of output, sunk during the succeeding ten years to 1·806 per 1,000 persons employed, or 5·654 per 1,000,000 tons of output, whilst in 1893, it was 1·552 per 1,000 persons employed, or 6·049 per 1,000,000 tons of output. The highest death-rate in any inspector's district was 2·638, and the lowest 0·797 per 1,000 persons employed, and 13·369 and 3·212 respectively per 1,000,000 tons of output.

From 1851 to 1854, I believe the deaths from explosions amounted to 25 per cent. of the total deaths, the average death-rate being 4·54 per 1,000 persons employed, or 16 per 1,000,000 tons of output.

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* Vol. v., page 623.

† A total of 265 deaths, or 24·99 per cent. from sundry causes underground.

In view of the great differences seen to exist in the death-rate between one inspector's district and another, it would be of value to elicit the precise conditions under which the respective districts are worked, so as to account if possible for these differences.

Whilst from time to time we are startled and shocked by the terrible mining catastrophes caused by explosions that unfortunately still occur, as so lately at the Albion colliery in South Wales, we yet notice how much larger is the proportion of the deaths from other causes. In reference to these I cannot doubt that with increased care the number will be largely reduced. To the marked and increasing intelligence of our workmen themselves, and to the ability and vigilance of our managers and overlookers, assisted so largely as they all must be by Institutions such as our own, I now look, far more than to legislative enactments or further Government inspection, for a material reduction in all classes of accidents.

Much attention has lately been directed to the subject of "accidents in mines," and especially as to the part that coal-dust may take in causing them, and reports by Commissions in our own country and in those of France, Prussia, and Austria have been issued in reference to them.

During the present year an English Commission appointed "to enquire into the effects of coal-dust in originating or extending explosions in mines, whether alone or in conjunction with fire-damp," has issued its final report, and on the like subject, or bearing thereon, have papers been read to the members by Professor Bedson, Mr. McConnell, Mr. Blackett, and others, and previously by Professor Marreco, Mr. W. Cochrane, and the late Mr. D. P. Morison.

It is difficult to assume, however complete any apparatus may have been by means of which experiments on the subject have been made, that the precise conditions that prevail in a working mine can on all points be truly represented in such experiments, yet all, I think, concur in maintaining that fire-damp, present in even small quantities and not otherwise dangerous, becomes more or less dangerous in the presence of coal-dust.

Glancing over these reports I gather from them :—

That Messrs. Mallard and Le Chatelier, members of the French Fire-damp Commission, in 1882, rejected the theory that coal-dust alone could be the cause of any serious danger, or that any colliery explosion of importance could be attributed, with any probability, to the action of coal-dust.

That the Prussian Fire-damp Commission in 1887 came to the conclusion that the presence of coal-dust, in the complete absence of fire-damp,

gave rise generally to an elongation or propagation of the flame projected by a blown-out shot of limited extent, however far the deposits of dust may extend in the mine-roads; but that there were certain descriptions of coal-dust, which if ignited by a blown-out shot, would not only continue to carry on the flame even to distances much beyond the confines of the dust deposits, but would also give rise to explosive results in the entire absence of fire-damp, which in character and effects were similar to those produced with some other dusts in air containing 7 per cent. of fire-damp.

That the English Royal Commission in their report of 1886 on Accidents in Mines seems to be satisfied that a blown-out shot, where highly inflammable coal-dust exists in great abundance, may, even in the entire absence of fire-damp, possibly give rise to violent explosion, or at any rate be followed by the propagation of flame over considerable areas, and even by the communication of flame to distant workings, where explosive gas-mixtures or dust-deposits in association with non-explosive gas-mixtures exist.

That the Austrian Fire-damp Commission in 1891 having made a large number of experiments with a variety of dusts, found that, without any admixture of fire-damp, nearly all kinds of coal-dust were ignited by a cartridge of $3\frac{1}{2}$ ounces (100 grammes) of dynamite lying unconfined, while many notoriously dangerous gases were less inflammable than other less dangerous ones, the fineness of the dust greatly increasing its sensitiveness and danger.

With the information afforded by the reports alluded to, and by the large body of evidence gathered, the English Royal Commission on "Explosions from Coal-dust in Mines," issued a report in June last. In it is expressed the opinion that a blown-out shot may under certain conditions set up a dangerous explosion, even where fire-damp is either not present at all, or only in infinitesimal quantities; but that in order to set up an explosion there must be a combination of circumstances which probably rarely occurs in the practical working of a mine. Thus the dust must be of sufficient purity, fineness, and dryness to be easily raised and to possess explosive qualities, and in sufficient quantities at the place where and at the time when a blown-out shot occurs. The shot-flame must be of considerable size and intensity, and must be propelled into the dust with great force. The position of the shot is also likely to affect the result. An explosion once initiated may, by the presence of coal-dust, be greatly intensified and extended over large areas.

The conclusions arrived at by the Commissioners I give in their own words. They are :—

The danger of explosion in a mine in which gas exists, even in very small quantities, is greatly increased by the presence of coal-dust.

A gas explosion in a fiery mine may be intensified, and carried on indefinitely, by coal-dust raised by the explosion itself.

Coal-dust alone, without the presence of any gas at all, may cause a dangerous explosion if ignited by a blown-out shot or other violent inflammation. To produce such a result, however, the conditions must be exceptional, and are only likely to be produced on rare occasions.

Different dusts are inflammable and consequently dangerous, in varying degrees; but it cannot be said with absolute certainty that any dust is entirely free from risk.

There appears to be no probability that a dangerous explosion of coal-dust alone could ever be produced in a mine by a naked light or ordinary flame.

I do not know that any of us will take very serious objection to these conclusions. There appears to me in them a certain amount of indefiniteness or uncertainty, suggesting that much farther consideration of the subject is still needed.

With reference to the question of "explosives," to the consideration of which our members, no doubt, will now give considerable attention, I would refer them to a paper by Mr. A. C. Kayll in last year's volume, giving a definition of the various mining explosives.* Many of these are already in daily use in our mines, and the experience gained by members using them placed on record would be valuable.

I hope the Home Office will, as I think it should, with the means at its disposal, take up the question and stamp with its authority such explosives as it finds can with safety be used under varying and, if possible, any circumstances.

At the present time a committee of the Institute, specially appointed, associated with which are the Inspectors of Mines of this mining district, is engaged in a series of experiments on explosives. A first report has just been placed in your hands, and furnishes a valuable contribution to our knowledge of the subject.

While desiring to limit as far as possible the use of explosives, yet to prohibit the use of gunpowder in all coal-mines, or of high explosives in any save in such as produce dust of a very exceptional character, would involve a cost at very many of our collieries (where the blasting of stone constitutes so considerable a part of their work) which they would without some considerable compensating advantage be unable to bear.

The Commission, however, seem unprepared to suggest that such a prohibition should be imposed in any case, save only after a full enquiry into the circumstances of the individual mine concerned.

* *Trans. Fed. Inst.*, vol. vi., page 346.

In view of the full discussion that will doubtless take place on this large and important subject, and of the legislation evidently foreshadowed, I will not further pursue the subject. A careful review, meanwhile, of the Government's reports alluded to, the valuable papers that appear on the subject in our *Transactions*, and of the complete report of the Explosives' Committee when issued, will help us to enter upon the discussion of accidents in mines with a greater hope of arriving at satisfactory conclusions.

We are indebted to Prof. Clowes and to Mr. A. H. Stokes for bringing to our notice their hydrogen and alcohol lamps for testing and estimating small percentages of inflammable gas, the presence of which would not be detected by any of our ordinary safety-lamps.

Fan ventilation up to date has been almost exhaustively treated on by our members. It would be a farther valuable contribution if those members who have erected what I may term "helping-up" fans underground would give the members the benefit of the experience derived from their application. I know that several members have such fans placed at considerable distances from the shafts, with the view of saving large outlays for farther sinking in order to secure increased ventilation. Excepting one by Mr. A. L. Steavenson, I am not aware that any other paper has been written on this subject.

I could have wished that greater progress had been made towards the working of coal by machinery. Many trials have been made with various machines, and with good results, but as yet there has been no general application of them. The difficulty and expense of providing and transmitting the needed power for driving them to remote distances has no doubt operated to delay progress.

If our thin seams are to be worked, the attention of mining and mechanical engineers must be directed to this subject. By the aid of funds for the purpose subscribed by colliery owners and others interested, a committee of suitable persons entering upon an enquiry would, I think, at any rate materially assist in exciting interest on the subject, and lead to some useful and practical result. Electricity will materially assist in getting rid of some of the difficulties alluded to, and already we are glad to note the rapid strides it is making in and about mines, carried readily and to remote distances for hauling, pumping, and lighting purposes. It will also, I think, lead to the introduction of locomotive traction under ground, as to which no progress seems to have been made since Mr. W. Lishman a few years ago introduced his air-locomotive at the Newbottle colliery.

We are indebted to the writers of several papers on electricity, printed in the *Transactions*, for giving their experience already gained from its use. We shall continue no doubt to receive enlarged information that will enable a judgment to be formed as to its suitability and economy for underground work under various circumstances.

Considerable attention has of late, as our *Transactions* show, been directed to improving the machinery for screening and cleaning coal. I might mention that during the past year the owners of Evenwood collieries have erected a very large and complete Luhrig plant for automatically sorting and washing coal. The system has been described by Mr. John Hogg and Mr. G. B. Walker.* As yet no other colliery in either Northumberland or Durham has adopted the system. Though it has involved a very large expenditure, I believe the colliery owners are perfectly satisfied with the results obtained, and may, I hope, be willing to allow its inspection and give the members full information as to its advantages and economies.

I shall not detain you longer, but can only add, in conclusion, that mining engineers are looking anxiously for whatever can be devised for securing increased economy in the cost of production. The thicker coal-seams are being rapidly exhausted, while others remain equal in quality but of greatly reduced section.

Over a somewhat large area, I have found that whereas twelve years ago but little if any coal was being then worked out of seams under 3 feet in thickness, yet out of the same area fully 22 per cent. is now being worked from seams under 26 inches in thickness, and this proportion is becoming yearly an increasing one.

The change, to a greater or less extent, prevails throughout the northern counties and elsewhere. It becomes, therefore, a serious problem for mining engineers to solve: namely, how best to meet so serious a falling off in section, involving as it does so largely increased cost.

To each member we look for giving the Institute the value of his experience, and for bringing to its notice whatever may be so found by him to lead towards this solution.

The PRESIDENT, in conclusion, said he was startled when, a few years ago, Mr. Simpson stated in his presidential address that of the original members of the Institute only seven remained. Of those who were

* *Trans. Fed. Inst.*, vol. vi., page 393; and vol. vii., page 392.

members of the Institute in 1852 only four now remained, and he was pleased to know that of these there was one whom they looked upon as their veteran mining engineer, and who as they hoped would yet be spared for many years to take an interest in the Institute—he referred to their friend Mr. William Armstrong.

Mr. J. B. Simpson proposed a vote of thanks to the President for his able and valuable address. A year or two soon passed, and there did not seem much that was fresh to record, but still Presidential addresses had the advantage of bringing continually before the members of the Institute both the wants and the difficulties in mining and the means of securing safety and economy; and their thanks were due to Mr. Douglas for the able way in which he had treated the various subjects of his address.

Mr. W. O. Wood said that it had frequently been a matter of wonder to him that their Presidents from time to time had been able to compass fresh subjects, and they must all admit that the present address lacked nothing in freshness and novelty, and must prove exceedingly valuable to all who had listened to it. He then seconded the vote of thanks.

The vote of thanks was heartily adopted, and briefly acknowledged by the President.

Mr. Alexander Siemens (London) read the following paper on "Electric Transmission of Power":—

ELECTRIC TRANSMISSION OF POWER.

By ALEXANDER SIEMENS.

At a meeting of the Iron and Steel Institute held in Newcastle-upon-Tyne in the year 1877, Sir William Siemens discussed the possibilities of transmitting power to a distance by means of the electric current, and called particular attention to the feasibility of utilizing the power running to waste at the Niagara Falls, which he had visited during the preceding year.

If the writer is not mistaken, it was this address which induced Lord Armstrong, a distinguished citizen of Newcastle-upon-Tyne, and a past-president of your Institute, to put up at Cragside a small electric plant for utilizing a waterfall in his grounds for lighting purposes at night and for motive power during the day.

Not long afterwards Sir William Siemens replaced a steam-engine by an electric motor for driving a pump near his country-house at Tunbridge Wells, and also employed the current for driving various farm-implements, in addition to the lighting of the house.

These applications of electric transmission were perfectly successful, and might have been imitated in many country-houses and elsewhere, but for a time lighting absorbed the attention of electrical engineers, and it is only lately that the transmission of power has been taken up in earnest.

First of all, electric tramways were developed, and their rapid extension is sufficient proof that reliable electric motors can be built which will work under very trying circumstances without giving trouble.

Most of the members will be acquainted with the papers read by Mr. Selby Bigge before this Institute* and the Iron and Steel Institute,† in which the subject is treated in a general manner, and some interesting examples are mentioned.

More recently, Mr. Richardson has dealt with the same subject in his presidential address to the North-East Coast Institution of Engineers and Shipbuilders, which has given rise to an interesting discussion.‡

* "The Practical Transmission of Power by Electricity," etc., *Trans. Fed. Inst.*, vol. iii., page 278.

† "Electricity as a Motive Power in the Iron and Steel Industries," *Journal of the Iron and Steel Institute*, 1894, vol. xlv., page 252.

‡ *Trans.*, vol. xi., page 13.

Under these circumstances it would be tedious if the writer repeated a description of the general features of electric transmission, and gave again the reasons for expecting economic advantages from the adoption of electric motors in the place of scattered steam-engines.

There is one point, however, which has not received, in the papers mentioned, the attention that it deserves, and that is the size of the motors employed.

One of the characteristics of an electric motor is that the current passing through it depends on the work which it is called upon to do, as the writer showed in a lecture before the Society of Arts in 1883.* The consequence is that, if the motor be only just powerful enough for its regular work, any accidental increase in its load will cause a current to pass, which may seriously damage the motor. This, in fact, is almost the only quality in which an electric motor compares unfavourably with other mechanical motors. If these are overloaded, they run more slowly or stop, but an electric motor is liable to destruction. Fortunately another quality of electric motors counteracts this disadvantage, and that is their comparative great efficiency at a diminished load. It is therefore advisable, for economic reasons, to employ comparatively large motors, although the first cost of an installation is increased thereby, but the absence of repairs will very soon repay the extra outlay.

Exactly the same result has been experienced with dynamos for lighting purposes, which at first were always worked to their full capacity, in order to obtain a large output with the smallest possible quantity of materials. You will find, for instance, that Prof. Tyndall, in his report to the Trinity House on electric lighting experiments at the South Foreland, lays particular stress on this point, and considers the lightest machine the best. When these dynamos were put on regular duty they worked for a few months very well, but afterwards their insulation broke down, and they gave so much trouble that they had to be replaced.

It would be a great pity if the same mistake were repeated with electric motors, and if any of the members contemplated the adoption of electric transmission in their works they should not forget to compare the sizes of the dynamos proposed as well as their cost. The latter alone is no criterion whatever.

The writer's principal object is to lay before the members some results of the adoption of the electric transmission of power at the Woolwich works of Messrs. Siemens Brothers & Co., where the change was commenced about two years ago, and is even now not quite completed.

* *Journal of the Society of Arts*, 1883, vol. xxxi., page 531.

The diagram (Fig. 1, Plate XIV.) shows a plan of the works, which cover about six acres of ground.

At the central station 12A, there are five boilers working at a pressure of 130 pounds per square inch, of the "gun-boat" type, *i.e.*, two-flued multitubular boilers, each 18 feet long and 9 feet in diameter. They are hand-stoked, and supply steam to the machinery of the central station, to the steam-engines driving the guttapercha shop, and for heating purposes.

Condensers are placed on the roof of the boiler-house, each sufficient for 25 indicated horse-power. These condensers consist of two cylinders, one placed inside the other, forming an annular space into which the steam passes from the engines, while cold water is trickling down the outside of the larger and the inside of the smaller cylinder. The condensing water is used to feed the boilers and to supply the guttapercha and indiarubber washing-tanks, and the condensed steam is allowed to run to waste.

In the engine room 12, which measures 42 feet by 30 feet, there are four steam dynamos, each capable of giving a current of 1,500 ampères at 120 volts pressure, when running at 350 revolutions per minute. All four dynamos are exactly alike, being two polar drum armature machines of the Siemens H.B. 24/36 type, shunt-wound, and fitted with switch and resistances for varying the exciting current by hand. Three of the dynamos are driven by three Willans III. compound condensing single-acting engines, and the fourth is coupled to a Belliss compound condensing double-acting engine (Fig. 2, Plate XIV.).

The four generating sets are coupled in parallel to an omnibus bar, with ampère indicators showing how much current each set is giving, and from this bar the main cables are laid to the various departments, a safety-fuze and an indicator being fitted in each circuit. Provision is also made on the switch-board for coupling two of the generating sets in series, when a current of 240 volts pressure is required at any part of the works (Fig. 3, Plate XIV.). The return cables are also all joined to one bar, and from this bar the current passes through a registering meter before it returns to the dynamos (Fig. 4, Plate XIV.). In this way an exact record is kept of the current generated at the central station. The total length of cable laid between the switch-board in the engine-room and the distributing boards in the various departments is a little over 18,000 feet, the area of the cross section of the copper conductor varying from $\frac{1}{4}$ to $1\frac{1}{2}$ square inches.

Each department has its distributing-board to which the current is brought from the central station by one or more main cables ; it is fitted with a registering-meter, and with fuzes for the branch cables which lead to the various motors in the department (Fig. 5, Plate XIV.).

All the main cables have the copper conductor insulated by impregnated jute, covered with lead, which in its turn is protected by tarred jute and steel ribbon, again covered with jute and compound. These cables are laid directly into the ground without farther protection, and have never given any trouble.

Owing to the rules of the London County Council, each motor is completely enclosed, and by no means readily accessible. Some motors are quite cased in with sheet iron, so that nobody may come in contact with moving parts. In other instances, an iron framing covered with iron netting is put round the motor, and this arrangement has the advantage of permitting a free circulation of air.

At the present time, 72 motors are in use, varying in size from 100 to one-sixth of a brake horse-power, and capable of giving a total of 1,407½ brake horse-power.

The output of the central station is 1,200 indicated horse-power, which (with an efficiency of 86 per cent.) gives 1,130 electrical horse-power available at the central station, or, roughly, 1,000 brake horse-power at the motors in the workshops.

With regard to these figures, it should be remembered that the whole plant is capable of producing from 25 to 30 per cent. more output, when required for a few hours, without any danger of straining any part of it, and this is the safeguard to which the author has already called attention, and which ensures the satisfactory working of such an installation.

Before the electric transmission was introduced, eighteen steam engines were employed, capable of yielding altogether 1,446 indicated horse-power. These correspond to about 1,150 brake horse-power, then available for driving machinery. Seven of the old steam-engines, giving about 380 brake horse-power, are still in use, so that the total power now at disposal for motive purposes is 1,787 brake horse-power, while, in addition, the central station furnishes current for 72 arc-lights and about 1,600 sixteen candle-power incandescent lights.

A comparison of these figures will at once show that the works have been considerably extended since the first steam-dynamo was started, on June 20th, 1892, and for this reason it has been rather difficult to find out how the cost of power at the present time compares with that of working steam-engines alone.

Another circumstance which made such an enquiry complicated was, that the work on a large cable contract this year increased all expenses of fuel and labour to such an extent, that the preceding years cannot be compared with it in order to determine the exact saving that has been effected.

In former years, cable work of equal duration increased our consumption of coal by nearly 5,000 tons, but this year the increase has not been more than about 2,000 tons, so that an actual saving appears to have been effected of about 3,000 tons of coal.

The steam-engines and boilers of the old installation were tended by ten stokers and nine engine-drivers, while at the present time eight stokers are employed, of whom three attend to the old boilers still in use, and five engine-drivers, three of whom attend to the old engines.

The electrical part of the machinery in the central station is attended to by one electrician and a boy, while the motors are attended to by the oilers of the various departments.

When the arrangements are completed, all auxiliary boilers will be abolished, and a farther saving of attendants will be effected.

As far as they go, these comparisons prove that the electric transmission has been economical, but in order to obtain satisfactory information as to the performance of the plant, a series of tests were conducted by the experiment department, under the direction of Dr. Eugin Obach, as follows :—

The boiler-tests and engine-tests were carried out separately in two series. The first series was intended to determine the weight of steam generated per pound of fuel, and this test extended over a month of ordinary working, and included all necessary coal for lighting up. The second series was intended to determine the weight of steam required by the engines, per Board of Trade unit delivered to the distributing bars of the central station switch-board. This was found by exhausting the engine under test into the main condenser, and measuring the overflow from the air-pump, taking care that no other water could mix with the overflow.

These engine-tests were subdivided again into two kinds :— (1) Running on steady artificial loads of about $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and full load ; and (2) running on the ordinary day load.

The second set of tests was undertaken to see if a varying day-load required the same weight of steam per Board of Trade unit as a perfectly steady load giving the same output. This was found to be the case, the point obtained by the day-load test fell exactly on the curve obtained from the steady load tests (Fig. 6, Plate XV.).

As factors involved in the cost of generating a Board of Trade unit, the steam taken by all the auxiliary pumps had to be taken into account. This was done by condensing the steam exhausted from the feed-pump, air-pump, and circulating-pump, and weighing the water discharged. As

the feed-pump supplied water to all the boilers, only a part of its steam was taken in the proportion which the air-pump discharging from the condenser bore to the total feed-water.

Coal.—The coal was weighed out of the barges in quantities of 15 cwts. at a time ; a reliable steel-yard was slung on the crane-hook and was compared from time to time with standard weights. A sample was taken from each skip, and all the samples were afterwards ground up and well mixed, thus affording a thoroughly representative sample of the coal for analysis.

Water.—The water was fed from a feed-water heater into a measuring-tank holding 6,270 pounds ; this tank stood over a shallow supply-tank, and could be emptied into it through a 6 inches valve. The temperature of the feed-water was frequently taken.

The test was started with a perfectly clean stokehold floor, the furnaces having been supplied from a separate store of coals, which was locked up as soon as the use of the weighed coals was commenced. The water-levels in the gauge-glasses were marked, and the steam pressures and state of fires were noted.

A log-book was kept, with the following entries :—(1) Time of shift (eight hours) ; (2) name of person in charge of shift ; (3) boilers in use ; (4) amount of coal weighed into bunkers ; (5) state of bunkers ; (6) pounds of water fed during shift ; (7) mean temperature of feed-water ; (8) mean steam-pressure ; and (9) water-level in feed-tank at end of shift.

At the end of the first week the boilers were worked down to the same condition as at starting, and all the coals used up, feed-water noted, etc., to form a check. Then the test was continued, and went on until the month was up, all the conditions being the same at the end.

Engines.—The engines and dynamos were run for five hours on each load, that is, four tests on each type of engine, eight tests in all on the steady loads.

Simultaneously, the auxiliary pumps, etc., were measured, and the electrical output of the dynamos was gauged.

The engines were indicated every half-hour, giving ten sets of diagrams for each load. To ensure simultaneous readings of the electrical instruments and indicators a whistle was blown.

Electrical Measurements.—The electric current was measured in two ways. (1) By three Siemens ammeters A53 type, which were frequently compared with the standards, in the positions in which they were used, and were set up in such a way as to have no disturbing effect on one another. The readings of these three instruments were adopted. (2) By

a large plate of german silver carrying the main current, and having its difference of potential measured at two points by a delicate galvanometer. The two methods described above gave very consistent results, particularly at the two lower loads.

The volts were measured by:—(1) A Siemens torsion-galvanometer, checked with the Clarke standard cell before and after all the tests, and found correct. (2) A Weston standard voltmeter. These two methods also agreed, the difference being quite negligible. The voltmeters were placed at a distance from any machines or cables carrying current. These readings were adopted.

To ensure the greatest possible accuracy in the efficiency tests, all the steam-engine indicator-springs were tested by an independent manufacturer, and a correction-table applied to the indicator-cards.

In making up the cost of a Board of Trade unit, the following items were included:—Coal, including cost of delivery to bunkers; water, auxiliary pumps, &c.; oil, waste, and sundry stores (for last six months); removal of ashes, engine-room drivers and machine-tenders, electrician and switch-board boy, stokers and repairs.

This cost only refers to the Board of Trade unit at the switch-board, and takes in no charges connected with the distribution-plant. The actual results obtained are stated below.

Boiler Efficiency—Boilers of gunboat type:—

	Square Feet.
Nos. 3 and 4 boilers, heating-surfaces—	
Tubes	1,033
Flame-boxes	222
Total	1,255
No. 5 boiler, heating-surfaces—	
Tubes	1,110
Flame-boxes	215
Total	1,325

The grate-area of boilers, Nos. 3, 4, and 5, was 41 square feet for each. The duration of test was 356⅔ hours. The total of boiler-hours was 988.

Nixon navigation coal was used, the mean thermal value of four samples being 14,221 British thermal units. The evaporative power at 212 degs. Fahr. was 14·65 pounds of water per pound of coal. The mean carbon value of the coal was 0·993. The coal burned per boiler per hour was 625 pounds, and per square foot of grate-area per hour, it was 15·25 pounds.

FIVE HOURS' TESTS OF A WILLANS III. COMPOUND CONDENSING ENGINE (No. 2), OF 300 INDICATED HORSE-POWER, COUPLED TO SIEMENS H.B. 24/36 DYNAMO, 1,500 AMPÈRES AND 120 VOLTS, AT 350 REVOLUTIONS PER MINUTE.

Experiment.	Indicated Horse-power.	Volts.	Ampères.	Watts.	Electric Horse-power.	Board of Trade Units.	Pounds of Coal per			Pounds of Steam per			Efficiency. Col. 5. / Col. 1.
							Hour per Indicated Horse-power.	Hour per Electric Horse-power.	Board of Trade Unit.	Hour per Indicated Horse-power.	Hour per Electric Horse-power.	Board of Trade Unit.	
													Per Cent.
1	95·75	120·7	376·2	45,407	60·87	227	2·29	3·945	5·28	20·5	35·2	47·15	63·6
2	149·2	120·05	712·3	85,511	114·6	427·5	2·35	3·06	4·10	21·0	27·3	36·6	76·8
3	209·8	119·75	1,106	132,443	177·5	662·2	2·24	2·656	3·55	20·03	23·7	31·7	84·6
4	268·9	118·2	1,459	172,453	231·2	862·3	2·18	2·545	3·41	19·5	22·7	30·45	86·0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

FIVE HOURS' TESTS OF A BELLISS COMPOUND CONDENSING ENGINE (No. 1), 300 INDICATED HORSE-POWER, COUPLED TO A SIEMENS H.B. 24/36 DYNAMO, 1,500 AMPÈRES AND 120 VOLTS, AT 350 REVOLUTIONS PER MINUTE.

Experiment.	Indicated Horse-power.	Volts.	Ampères.	Watts.	Electric Horse-power.	Board of Trade Units.	Pounds of Coal per			Pounds of Steam per			Efficiency. Col. 5. / Col. 1.
							Hour per Indicated Horse-power.	Hour per Electric Horse-power.	Board of Trade Unit.	Hour per Indicated Horse-power.	Hour per Electric Horse-power.	Board of Trade Unit.	
													Per Cent.
1	79·4	120·02	376·0	45,127	60·49	225·6	2·99	3·91	5·24	26·7	34·9	46·8	76
2	144·75	120·05	747·6	89,749	120·3	448·7	2·72	3·28	4·39	24·3	29·25	39·2	83·3
3	212·8	120·32	1,116·8	134,373	180·12	671·9	2·48	2·94	3·94	22·2	26·26	35·2	84·7
4	271·6	121·22	1,418·0	171,890	230·4	859·5	2·51	2·95	3·95	22·4	26·33	35·3	85·1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

The water evaporated per boiler per hour was 5,576 pounds. The weight of water evaporated per pound of coal (including coal used in lighting fires) into steam at a pressure of 127 pounds per square inch was 8·923 pounds. The weight of water evaporated per pound of coal from and at 212 degs. Fahr. was 10·083 pounds. The weight of water evaporated per square foot of total heating-surface per hour was 4·42 pounds. The weight of water evaporated per square foot of grate-area per hour was 136 pounds. If the coal used in lighting up be neglected, the evaporative efficiency becomes 9·16 pounds of water per pound of coal at a mean pressure of 127 pounds per square inch, and 10·35 pounds of water per pound of coal from and at 212 degs. Fahr.

The annexed experiments were made on steady loads (resistance frames):—

Day-load Tests of Five Hours, the Variation of Load being about 15 per Cent.

	Willans Engine, etc.	Belliss Engine, etc.
Mean current (ampères)	1,167 ...	1,184
Mean pressure (volts)	121·33 ...	126·38
Mean power (watts)	141,592 ...	149,634
Mean electric horse-power	189·8 ...	200·6
Board of Trade units	797·96 ...	748·17
Weight of steam used per electric horse-power per hour (pounds)	23·39 ...	26·2
Weight of steam used per Board of Trade unit (pounds)	31·35 ...	35·1
Weight of coal used per electric horse-power per hour (pounds) ...	2·62 ...	2·93
Weight of coal used per Board of Trade Unit (pounds)	3·51 ...	3·93
Proportion of full load	0·778 ...	0·789

These engines were not indicated, owing to the impossibility of taking simultaneous readings.

From these experiments, two diagrams have been prepared, one showing the steam-consumption per Board of Trade unit, per electric horse-power, and per indicated horse-power (Fig, 6); and the other the efficiency of the steam-dynamos (Fig. 7, Plate XV.).

It will be seen that the steam-consumption of the Belliss engine was greater than in the Willans, but it should be stated that this was the first engine of its kind ever built of that description, and that it has the worst position as far as the exhaust steam is concerned. On the other hand, the efficiency shows to greater advantage in the Belliss set, the dynamos being identical.

After the consumption of fuel and of water had been determined by these experiments, the value of the stores issued to the central station for the last six months was ascertained, together with the wages paid and the cost of the repairs done to the central station and to all the electric plant, including motors.

The out-put of the station had been at the rate of 1,797,120 Board of Trade units per annum, representing a load factor of 0·285. The actual cost per Board of Trade unit was, therefore, for the six months ending October 31st, 1894 :—

	Per Board of Trade Unit. Willans. Pence.	Belliss. Pence.
Coal (including cost of delivery and removal of ash), 17s. 5d. per ton. Willans, 3·41 lbs.; Belliss, 3·95 lbs. per Board of Trade unit	0·3180	0·3680
Water (7½d. per 1,000 gallons)	0·0228	0·0264
Stores, oil, waste, boiler-fluid, etc. (taken from last six months' consumption) ...	0·0416	0·0416
Wages, stokers, trimmers, drivers, labourers, electrical assistant (half-time), and switch-board boy	0·0977	0·0977
Steam for auxiliary pumps, feed (only 0·7 taken), air and circulating, water 0·003d., coal 0·026d.	0·0290	0·0290
Repairs to central station plant and motors	0·0802	0·0802
Total cost per Board of Trade unit ...	0·5893	0·6429
Total cost per electric horse-power per hour...	0·440	0·480

The cost for steam supplied to auxiliary pumps, etc., is too high, as there was only one set exhausting into the main condenser during the tests, and the steam of one circulating-pump and the air-pump was charged to this set: probably a very little more steam would suffice for the full working load on the condenser.

This cost is that of a Board of Trade unit at the switch-board in the central station. The loss of energy in the cables is not more than 5 per cent., and the average efficiency of the motor being taken at 90 per cent., the cost of a brake horse-power or 746 watts may therefore be taken at 0·515d. per hour.

No attendance has been charged to the motors, and the expense of oiling is very trifling, especially in motors fitted with Meneely bearings, of which a model was shown. Such bearings were applied to the three bearings of a Siemens H.B. 15/20 motor, developing about 40 brake horse-power at 360 revolutions per minute in driving part of the machines in the

lead-cable-sheathing shop. Two of the journals are $2\frac{3}{4}$ inches in diameter by $7\frac{3}{16}$ inches long, while the third is $3\frac{1}{4}$ inches in diameter by $6\frac{7}{16}$ inches long. During the first week's run, one of the roller-bearings got rather hot, but not sufficiently so to necessitate stopping the motor; and since that time, the beginning of July, 1893, they have all been running satisfactorily. The consumption of oil, after the first few weeks, was at the rate of one pint per month for the three bearings.

In order to make a comparison between the outlay for an electric plant, and for a steam-plant, the author has had a table prepared, showing the cost of the old steam-engines and boilers at Messrs. Siemens' works, together with the cost of foundations, erection, and of the chimneys. A statement, similarly, of the cost of the new boilers, of the pipe work, of the auxiliary engines, the condensers, the steam dynamos, the cables, motors, switches, and all accessories has been also prepared.

In the old steam-plant of 1,446 indicated horse-power, taking into account the long lengths of shafting that had to be driven, the author does not think that more than 60 per cent. or 867 brake horse-power, was really utilized. On the other hand, there are now 1,407 brake horse-power available at the motors, and 240 horse-power devoted to electric-lighting purposes.

The author does not wish to publish the exact costs, but the capital outlay per brake horse-power was 30 per cent. higher in the case of the old steam-plant, than for the present electric central station plant. Moreover the load factor, viz., the proportion of the actual output of the central station to the possible output, which, as stated above, is 0·285, shows that we can connect to the present generating-plant many more motors without much fear of overloading it.

There can therefore be little doubt that for new works, electric transmission of power is certainly more economical than the employment either of separate steam-engines or of transmission by belts or ropes.

Whether a change from the old system to electric transmission can be recommended depends entirely on local circumstances, and this question can only be ascertained by carefully weighing all the factors that come into play. Generally speaking, electric transmission is most applicable where power is wanted at a number of places scattered over the works, and especially in and about mines and collieries.

Such a case has lately been investigated by the writer's firm, and they have made an offer to replace various engines, exerting altogether about 800 brake horse-power, by an electric plant, comprising a central station similar to that at Messrs. Siemens' works, but having only three boilers

and three sets of steam-dynamos, all switches, cables, and motors to do the above work for a certain sum. By this conversion the colliery owner would save sufficient money, counting 15 per cent. of his outlay for interest and depreciation, to repay the outlay in ten years, or in other words the cost of working the plant for a year would be less than the present cost by an amount equal to 25 per cent. of the outlay.

These figures show that there is a wide field for successfully applying electric transmission of power, in works as well as in mines, where electric motors must be especially welcome, as they do their work without forming any bye-products that have to be dealt with by costly contrivances.

In these times of ever-increasing competition it is well worth while to utilize all advantages that science places at the disposal of industry, and anything that increases the amount of power at our disposal for each pound of fuel consumed, should meet with hearty support in this great centre of mining and industry.

Mr. A. Siemens supplemented his remarks by referring to the existing electric locomotives on the South London Subway. Messrs Siemens Brothers were asked to supply two locomotives (each carrying two motors) to be used in place of others which had not given entire satisfaction: and on their delivery considerable comment was made as to the great size of the motors. It was contended that it was an obstacle to the adoption of electric traction to put in motors like an elephant to do a donkey's work. But these motors being so very large for their work took very little current, and the heating of the armature was practically *nil*. After the first experimental run along the line, the engineers of the company applied thermometers to the armature, and were astonished to find that there was no perceptible increase of temperature. In regular working, it had been found that the Siemens locomotives did the work with 50 for which other locomotives required 80 ampères, the difference being due to the fact that the motors on the other locomotives were a little smaller, and consequently got hotter when in use. By adopting the larger size of motor, 40 per cent. of the current was saved, and this saving was worth considerably more than the interest on the difference of first cost. The Siemens locomotives had run over 60,000 miles without any repairs, and the first pair of brushes was still in use. He referred to this question because it was often contended that an electric motor frequently cost more in brushes than a steam engine did in coals. He (Mr. Siemens) suggested that if electric motive power were introduced into mines for hauling, etc., the same

mains might be used for lighting purposes. He was reminded that he was now speaking in Newcastle, and therefore instead of taking the price of coal (including the removal of ashes) at 17s. 6d.,* he might reduce it to one-third, say 5s. 10d. per ton. Under these circumstances, the cost of the Board of Trade unit would be: Willans engine, etc., 0·377d.; Belliss engine, etc., 0·390d.; and the cost of an electric horse-power, 0·28d. and 0·29d. respectively.

Mr. C. A. Parsons (Newcastle-upon-Tyne) wrote that he thought the members were very much indebted to Mr. Siemens for the valuable practical information contained in the paper. As far as he knew, it was the first reliable information which had been placed before the public with regard to the cost of transmission of electrical energy to short distances. It seemed to him that electric transmission was undoubtedly the cheapest and most economical method of distributing power to scattered or irregularly arranged works, and as such, one of its best fields would be to replace numerous small engines in existing works which had grown up bit by bit, as the requirements of business had necessitated additional departments and buildings. Whether it was the best means of distributing power in a new works where the buildings were compactly arranged seemed to be at the present time a matter of some doubt, as it could not be denied that the capital cost and the maintenance in motion of shafting and a small amount of belting would be less than that of an electrical installation of dynamos and motors and connecting-wires. It would be interesting to know the objects that Mr. Siemens had in view in adopting the form of condenser which he described, in preference to a cooling-pond and an ordinary surface-condenser. It would also be interesting to know what vacuum was obtained from these special condensers. The figures of steam consumption per electric horse-power were most interesting, as he believed that they were the first reliable independent tests that had been made with Willans and Belliss engines under ordinary working conditions. Mr. Siemens figures appeared to be somewhat higher than those obtained on special tests; this, however, he believed, was always the case, owing to small leakages and other losses which were present in steam machinery under ordinary working conditions. He (Mr. Parsons) had the pleasure of seeing Messrs. Kinoch's works at Birmingham recently, where each shop is worked by one electric motor driving several lines of shafting by belts, the current being generated from a central station. The buildings of this explosives factory are necessarily scattered, with a view of minimizing the danger from explo-

* *Trans. Fed. Inst.*, vol. viii., page 256.

sion, and consequently electrical transmission of power is there eminently suitable. There were many other manufactures in which similar applications of electricity could be used to advantage.

Mr. W. O. Wood asked Mr. Siemens to explain how it happened, in the case of the load suddenly being taken off, that the motor, instead of running away, automatically adjusted itself to the load and current, even when the generator was placed at some distance!

Mr. Henry Lawrence said that the author showed an economy of 30 per cent. in favour of the electric motor when compared with an ordinary steam engine for the same amount of work. He understood that Mr. Siemens in making his experiments did not take exactly what the dynamo and electric motor were doing but what they might do, and he did not think this was a fair method of comparing the horse-power obtained by the electric motor with that obtained by the ordinary steam engine. Again, the writer mentioned that if the machinery were cut off from the steam engine it would run away. If that were so, it must have been an old-fashioned engine and the engineman could not know his work, for with the Corliss type of engine and other similar engines he had suddenly thrown 300 horse-power off an engine without being able to detect a difference of two revolutions in its speed.

Mr. A. L. Steavenson said that the subject of electric-power transmission had been so frequently brought before the members that he hesitated to enter again into the discussion, but he thought it would hardly be fair to Mr. Siemens not to raise a few points for his consideration. He quite agreed with the remark that "Whether a change from the old system to electric transmission can be recommended depends entirely on local circumstances, and this question can only be ascertained by carefully weighing all the factors that come into play." It was hardly fair to compare an old works, where the engines had as it were dropped from the clouds, with pipes, probably uncovered, extending in all directions, with a new works erected with the experience of present knowledge on the subject. If, in comparison with Messrs. Siemens' works, he (Mr. Steavenson) were to take a similar works, and put down a new plant, using such motive power as he chose, he had strong doubts as to whether at the end of ten years the balance would be in favour of electricity. At the close of the paper the author stated that "these figures show that there is a wide field for successfully applying electric transmission of power in works as well as in mines." He (Mr. Steavenson) was inclined to join issue with the writer, for he had already on several occasions inculcated caution. With high pressures or low pressures there was the risk of fire. In roads

in mines wires might be covered, but they were left for many hours together, and if a short circuit occurred, the result was to ignite the timber and coal, a state of affairs which might have most serious consequences. He pointed out at the Newcastle meeting of the British Association that the special features of coal-mining required great caution in the use of electricity, the lowness of the seams necessitating the cables being placed within easy reach; and there was also the fact that it was dark, and a man might, without noticing what he was doing, make a false step, put out his hand, touch the cables, and receive a serious shock, or even be killed. Mr. W. H. Preece objected to this statement, and a discussion had arisen as to what he (Mr. Steavenson) really said. On September 24th, 1889, Mr. Preece wrote to the *Times*, and said that "what I did characterize as absolute nonsense was the reason which a mining engineer adduced against electrical currents for transmission of power in mines, viz., that a man who touched such a wire would be killed; such currents are invariably direct currents of low pressure, and are therefore quite safe." But in the *Electrical Review** there is a paragraph as to a fatal accident from this very cause as follows:—

> On Thursday last, James M'Inulty was killed instantaneously by coming in contact with the electric haulage-apparatus in Bogside pit, belonging to the Lanemark Coal Company. While in the act of lifting a hutch, the side of his head touched a defective casing in which the electric wire runs, and stuck fast. Another miner caught hold of him, but was thrown off by the shock. Presently the driving engine was stopped, and the body of the man fell lifeless.

He was, therefore, not talking "absolute nonsense," and the paragraph proves that mining engineers should use electricity with great caution, and he had endeavoured to impress upon those who heard his remarks at the meeting of the British Association that whilst electricity was a good servant it was a dangerous master. His advice was when using electricity not to use high-tension or alternating currents. The question arose as to what was a safe current, and on this subject he might quote from the report of the Health Committee of New York (October 15th, 1889), where a large number of fatal accidents had occurred:—

> It is our opinion, based upon our own experiments and authentic records, that an alternating current of 250 volts is dangerous to the life of any person through whose body such a current may pass. Also, that a continuous current of 700 volts is in like manner an unsafe amount of electrical force to be permitted to be used upon an imperfectly insulated wire.

But what is insulated? Mr. Edison says, "that the wearing out of the insulation is accounted for by the fact that the vibrations of the current cause corresponding vibrations of the insulating material and impairs its elasticity.†"

* November 30th, 1894. † *Engineer*, December 20th, 1889.

He would say, in conclusion, go on using electricity (as he himself was doing), but use it under safe conditions.

Mr. C. C. Leach said that at Seghill colliery the electric power plant only developed 32 per cent. of useful effect. He would like to know what was the useful effect of Messrs. Siemens' plant?

Mr. Siemens—73 per cent.

Mr. Leach said that the Seghill plant only yielded 32 per cent. on the water delivered compared with the indicated horse-power.

Mr. Siemens said that the useful effect of the plant would depend upon the efficiency of the pump. If the pump had an efficiency of 80 per cent., it would give 58 per cent. as the efficiency from the indicated horse-power. If Mr. Leach would give him full details he might be able to suggest an improved plant.

Mr. R. C. Jackson (Newcastle-upon-Tyne) said the only remark that he had to make upon this very valuable paper was in connexion with the steam efficiency of the plant as determined at Messrs. Siemens' works. This was obtained by high-speed engines of the Willans and Belliss types coupled direct to continuous-current dynamos. It was a difficult matter to ascertain the steam efficiency either per indicated horse-power or per Board of Trade unit, and the Newcastle Electrical Supply Company had been at considerable expense and trouble to carry out a series of steam-consumption trials in connexion with their plant, which consisted of slow-speed horizontal engines, with rope driving, and alternating dynamos. He thought it would be admitted that alternating dynamos for similar outputs would have an efficiency of 4 per cent. less than continuous current machines of similar output. Again, there was an allowance to be made for the loss due to the rope driving. They had endeavoured to ascertain the amount of that loss, and he was inclined to reckon it at from $3\frac{1}{2}$ to 5 per cent. for an engine of 200 to 300 horse-power of good class. Taking a plant under these conditions he found in practical working, for engines working from $\frac{5}{4}$ to full load, that they could produce a Board of Trade unit with 32 to 33 pounds of steam, and this result, he thought, would compare very favourably with those obtained with high-speed engines. Of course high-speed engines cost less in the first place, but against that they had Mr. Siemens' own dictum as to having a sufficient margin in hand. If anything went wrong with a high-speed engine there was no time to attend to it; either they could run or they could not. On the other hand, slow-speed machines of the Corliss type always gave some indication to the engineman, and there was generally time to have the matter attended to. With a high-speed plant it was obvious

that it would be essential to have a larger proportion of spare plant available, and that would to a certain extent increase the first cost and area of floor space covered.

Mr. A. L. Steavenson agreed with Mr. Jackson's preference of a slow-speed Corliss engine to any of the high-speed engines he referred to, as permanent solid work was much more likely to be got from them.

Mr. C. W. Hutchinson (Newcastle-upon-Tyne) said that it would be valuable to know the result of Mr. Siemens' experiments as to the efficiency of machines of various sizes. It would also be of interest to know what was the best manner of reducing the speed of the motor, and likewise the actual speeds employed. One great factor of the subject of electric power-transmission was that intermittent work would be found to give the greatest economic results, greater at any rate than constant work.

Prof. Stroud (Durham College of Science) said that from a scientific standpoint there were several points for consideration in connexion with the subject of electric transmission of power; such, for example, as the distribution of power in isolated parts of works by means of fixed electric cables. The power required was proportional to the current being used or to the work being done, whereas in the case of mechanical systems some power must always be wasted in driving shafting, etc., even when only a few of the tools are in use. He endorsed Mr. Steavenson's remarks as to the care to be taken in connexion with electric power-plants; and, in connexion with mining installations, it was especially necessary that great care should be exercised.

Mr. L. Newitt (Newcastle-upon-Tyne) said that according to the paper the transmission of power over short distances now resolved itself into a comparison of electrical methods against shafting, belting, and steam pipes. Mr. Siemens said that "electric transmission of power is certainly more economical than the employment either of separate steam engines or transmission by belts or ropes.* On making a rough estimate of the efficiency of the electrical system as compared with shafting and belting, the following results were obtained:—In an electric plant for power-transmission, one might estimate the loss in the dynamo at 10 per cent., in the motor at 10 per cent., and in the cables at 5 per cent., a total of say 25 per cent. These figures must be almost correct, seeing that Mr. Siemens had estimated the loss at 27 per cent. In transmission of power by shafting, properly laid out and kept in good order, the losses due to friction would average from 6 to 10 per cent. This might seem very low, but from data which had been obtained at various

* *Trans. Fed. Inst.*, vol. viii., page 257.

times it seemed very near the mark. As an example of easy working, a line of shafting, 300 feet long, and 3 inches in diameter was set up, and when tested it was found that the whole length could be turned by two men exerting their weight upon a pulley 6 feet in diameter—that would be roughly 300 lbs. weight at a radius of 3 feet. Three similar lines of shafting had been tested with similar results. In the case of belt-transmission, it was found that tight belts were a great source of loss of power. If belts were, wherever possible, laid horizontally and somewhat slack, very little power was absorbed, probably not more than 6 per cent. The span over which belts work satisfactorily may, for the present case, be taken at 60 feet. It may be of interest to the members to know that in a large works on the Tyne, the average life of the main belts was about 18 or 20 years. Neglecting the losses due to friction in the main engine in each case, the losses due to shafting being 10 per cent., and adding the loss in belting of 6 per cent., the total loss in transmission of power over an area of 300 feet by 60 feet was 16 per cent.; whereas by electrical transmission there was a loss of 25 per cent. It appears therefore that in cases where the machinery was placed adjacent to the main engine he (Mr. Newitt) did not see how it was possible to have any system of transmission of power as efficient as that in use at the present time, viz., belting and shafting. The conditions, however, were entirely altered when it became necessary to run long lengths of steam-piping to separate engines. He (Mr. Newitt) thought that this was the great field for electric transmission, and that it should not be applied in ordinary compact works. In confirmation of this statement he would refer the members to the presidential address read by Mr. Richardson before the North-East Coast Institution of Engineers and Shipbuilders, from which it would be seen that the amount of leakage and condensation, which took place even in comparatively short lengths of steam piping, brought down the efficiency, in some cases, to as low a figure as 25 per cent.* The saving of coal pointed out in the paper led one to the conclusion that it was to a large extent due to the use of improved engines and boilers as well as to electric transmission. It would be interesting if Mr. Siemens could give some idea of the saving of coal due to the improved engines and boilers and also the saving due to the electrical transmission. In the earlier part of Mr. Siemens' paper the sizes of the electric motors were referred to, and their general efficiency was estimated at 90 per cent. This efficiency was probably true for large motors of 10 horse-power and

* *Trans.*, vol. xi., page 13.

upwards, but in several cases recently coming under his (Mr. Newitt's) own notice the efficiency of small motors, under 1 horse-power, had been less than 40 per cent. This defect in small electric motors appeared to be a bar to their individual application to small lathes or other machines, and he (Mr. Newitt) would be glad if Mr. Siemens would give some information upon this point.

Mr. R. Laverick asked whether some system of safety-plugs or cut-outs could not be adopted to prevent the possibility of too much current going through the motor and damaging or destroying it?

Mr. D. Selby Bigge (Newcastle-upon-Tyne) said that Mr. Siemens' paper would undoubtedly prove of the greatest interest, not only to the members of this Institute, but to all who were interested in the question of the electric transmission of power, and he must confess that to a great extent it supplied a link between the various papers that he had had the privilege of reading on the same subject, to which Mr. Siemens had alluded, and Mr. Richardson's most excellent presidential address. Mr. Siemens had confined himself largely to dealing with the question of the cost of production of electrical energy per Board of Trade unit and per electric horse-power, taking the case of Messrs. Siemens' works as an example, and had carried out a large number of experiments in order to arrive at that cost most accurately, but it appeared from the paper that this cost stopped, as it were, at the switch-board. He thought the information given by Mr. Siemens would have been still more interesting and valuable had he carried the matter a little farther, and given by experiments the exact coal-consumption per brake horse-power delivered by the motors; that is to say, the actual coal-consumption with all losses included throughout the entire canalization of mains, switching-gear, motors, speed-regulators, etc. Mr. Siemens valued the cost of a brake horse-power at 0·515d. per hour, but this was rather upon assumption. In his (Mr. Bigge's) opinion, the taking of the average working efficiency of all the motors at 90 per cent. was rather too high. He would ask Mr. Siemens if he could give any comparisons as to the total cost of production between, say, a large slow-running plant of 1,200 horse-power with triple-expansion engines, and of a plant of four smaller high-speed compound condensing engines of 300 horse-power each. Electric transmission of power must inevitably come to the front, both for long-distance transmission in mining and short-distance transmission in works, as the economical advantages to be derived from the system were plainly visible to all who examined and took an interest in these matters. During the last four years he had dealt with about

10,000 horse-power of electric motor work, and he had found that it was most important, as Mr. Siemens had pointed out, to have an ample margin of power in the motors.

Mr. D. B. Morison (Hartlepool) said that he was not a mining engineer, and was therefore not competent to estimate the probable economies to be effected in replacing steam by electric-power installations at collieries. But if collieries were worked at the same extravagant rate as the average shipyard and engine-works of this district, then he could say with certainty that the adoption of electric driving would be a commercial success. Mr. Siemens had given the members an extremely valuable and interesting paper, which contained the results of actual experiments most carefully made. Only those who had been personally engaged on experiments of this nature could appreciate the immense labour and expense in the preparation of such a contribution as that which Mr. Siemens had placed before the members of the Institute. He quite agreed with Mr. Siemens with regard to the imperative necessity of allowing a margin in the size and capacity of dynamos and motors for practical success, as nothing would retard the legitimate progress of electric driving so much as small, carelessly constructed, cheap, and unreliable installations. They might be sure that as electric driving became popular, competition would become keener, and there would be a tendency to produce cheap machines; but if those who adopted electric driving did not deal with experienced and reliable firms and accept their advice, they would find electricity a very doubtful blessing. The most interesting part of the experiments, from a commercial point of view, was the saving of 3,000 tons of coal per annum and the wages of six men, and there could be no doubt that when the transformation was complete there would be a farther economy of both coal and labour. He did not think Mr. Siemens could be aware of the almost universal extravagance in steam-driving in this district or he would not have allowed such an opportunity to pass without making a few comparisons. He had, however, said nothing, and therefore very considerately let them down far more gently than they deserved. He (Mr. Morison) lately had opportunities of testing steam-installations and of obtaining particulars of trustworthy tests, and the fact was indisputable that the consumption of steam of an average engine-works and shipyard was from 40 to 50 pounds per indicated horse-power, whilst there were not a few instances in ironworks of 80 to 100 pounds. In one case, where scattered steam engines in an open yard were replaced by electric motors equivalent to 35 horse-power, the change resulted in the saving of 30 tons of coal per week and the abolition of two steam-boilers with

their attendants. The consumption of steam in Messrs. Siemens' engines was about 22 pounds per indicated horse-power. This was accomplished by means of compound engines, and could be possibly reduced to 13 or 15 pounds with the highest class of triple-expansion engines. He had recently had the opportunity of inspecting an electrically driven works where an electric horse-power was produced for about 20 pounds of steam as against 25 pounds at Messrs. Siemens' works. Consequently the figures which had been put before the members were well within actual practice, and certainly were not extravagant or misleading assumptions. The question after all was a commercial one: it was a comparatively easy matter to ascertain the present cost of steam-power at any particular works, the economy which would result from the conversion to electric transmission, and the total cost of the transformation. He (Mr. Morison) said, however, that in such works as he had had an opportunity of examining, and allowing 15 per cent. for interest and depreciation, he was convinced that the capital outlay would be returned considerably within the period of ten years mentioned by Mr. Siemens. This economy, however, of course depended entirely upon existing conditions, and would vary according to circumstances. There were many compact works, of course, where high-pressure condensing steam-engines could be applied direct to the shafting, and in such cases the economy obtainable by electric driving would be confined to that gained by independent motors for cranes or heavy machines. It was not such works as these, however, where the great field of application was, but rather in yards and factories, where there were large numbers of scattered engines which were now working with an altogether unnecessary and extravagant consumption of steam and coal.

Mr. John H. Holmes (Newcastle-upon-Tyne) said that there seemed to have been some doubt thrown by some gentlemen upon the efficiencies obtained by electrical methods, and he would only like to corroborate the results which Mr. Siemens had submitted by quoting some tests made by Prof. Alex. B. W. Kennedy, on a set, the dynamo of which was constructed by his (Mr. Holmes') firm, tested at Messrs. Willans & Robinson's works near London. Although the plant was of considerably less power than that described in the paper it had an electric efficiency of 85·6 as against the 86 per cent. mentioned in the paper. The pounds of water used per indicated horse-power were 17·4 as compared with 19·5; and the pounds of steam per electric horse-power were 20·3 as against 22·7, and per Board of Trade unit 27·3 as against 30·45. The slight difference in favour of his plant may have been due to the fact that

the water used for working the air-pump was not taken into account. There was very little difference between these figures, and any person desiring to introduce electric transmission might confidently adopt them as fairly representing the average efficiencies that could be obtained by the makers of modern electric machinery.

Mr. Crawford (London), referring to the diagrams (Figs. 6 and 7, Plate XV.) comparing the efficiencies of the two types of engines, said that water consumption was only one measure of the value of an engine, and while being fully aware of its influence on the total efficiency, he thought its importance had been exaggerated by non-practical engineers. The efficiency curves (Fig. 7) were interesting and more valuable than the other (Fig. 6), but it should be borne in mind that the efficiency shown in Fig. 7 was not the total efficiency. Such important factors as endurance and reliability had not been compared, because they could not be determined in so short a period as six months. In his opinion the simplicity, accessibility, and want of novelty in the Belliss engine were all in its favour, and the reasonable probability (from considerations of strength, pressure per unit of wearing surface and type), was that the double-acting engine would be the most enduring and reliable. His remarks might be taken to apply to the whole of Mr. Siemens' paper, and shortly, he meant to say that it was easy to excel in any one direction, but it was much more difficult to secure all-round excellence.

Sir B. C. Browne asked, in the case of a shipyard or engineering works adopting an electric plant, what was the smallest size of motor Mr. Siemens would advise them to adopt? If they had a number of machines of different sizes requiring different powers to drive them, what would be the standard size of motor, and how would he group the machines? With reference to mines, had the difficulty of working in a wet or damp atmosphere been entirely got rid of? Some comparisons had been given of the worst cases of steam-engines with the most efficient electric plant. This might be very interesting, but he thought it was not of the smallest conceivable practical use; they must compare steam at its best with electricity at its best.

Mr. Siemens said he thought it perfectly fair that he should say to the owners of shipyards and other works, "Your existing machines are wasteful; supplant them by electric transmission, so that you may obtain a great saving." If there was a new works to be established, it was right to compare the best practice of the steam engine with the best practice of electric power-transmission; but, with regard to existing works, he thought it quite right to point out that if wasteful steam-engines were

abolished electric power-transmission could be substituted with great advantage. With regard to new works, the advantages had been referred to by Mr. Selby Bigge when he described the investigation which was made with regard to the Small Arms Factory at Herstal, which he (Mr. Siemens) also described before the Birmingham Institute in March, 1893. The Belgian engineers made a careful and detailed investigation as to how they should transmit the power, whether by ropes, belts, scattered steam engines, or by electric transmission, and thus the best practice of steam was compared with the best practice of electric power-transmission to the advantage of the latter. He was careful to say at the conclusion of his paper that "generally speaking, electric transmission is most applicable where power is wanted at a number of places scattered over the works, and especially in and about mines and collieries." If they wanted to investigate whether they should use electric power-transmission or not, they must make the comparison with what they had got. He ventured to say to Mr. Holmes that he should not compare a special trial at Messrs. Willans & Robinson's works, where everything was done to make the efficiency as great as possible, with these tests which were brought before the members as the results of actual working conditions, and which could be reproduced at any colliery or shipyard with certainty. Mr. Parsons asked why a particular form of condenser was used. The reason was simply because they happened to have them, and they gave a vacuum of 26 inches. Mr. Wood had asked for an explanation of the automatic adjustment of motors to their load. To answer this question, however, would take him too long, and he must refer him to the paper which he had read before the Society of Arts.* With reference to the life of electric plant, there was really nothing to wear out except the motor, and he had already pointed out that this should be made amply large for its work. In regard to the danger of shocks, Mr. Steavenson surely had not taken into consideration that all conductors should be insulated, and in his paper he was, of course, speaking of first-class work, properly done, by people who understood their business, and one of the principal conditions was that they could not get a shock anywhere. Therefore the question of danger he thought did not enter into the case. The way in which power was to be transmitted to the machines and the smallest motors to be recommended were points raised by more than one speaker. This depended entirely upon circumstances. They had $\frac{1}{4}$ horse-power motors coupled direct to fans, which naturally could not be driven from shafts. They had another small motor coupled direct to an emery-wheel for sharpening

* *Journal of the Society of Arts*, vol. xxxi., page 531.

tools, etc., and a number of motors ranging from 4 to 40 horse-power, driving groups of machines, shafting, and so forth. The power of the motor to be employed was therefore simply a matter for consideration in each case. If they had a number of lathes, and each one was only used occasionally, they could, of course, put one to each lathe, but it would be extravagant. The same sized motor could be put to a shaft to drive the six lathes, and it would have sufficient power to drive each lathe when wanted, but of course it might not be sufficient to drive all six together. Mr. Jackson had referred to steam efficiency, and was rather of opinion that his way of rope-driving was nearly as efficient as direct driving; but he (Mr. Siemens) might remind them of Mr. Crawford's remark that all the circumstances should be taken into account. In visiting such a station as that of the Newcastle Company, they would be struck with the great waste of space. Direct-driving machinery of four times the power could have been put into the same space. Space might be cheap, and therefore it was not so necessary to save it, but it was sometimes a material consideration in deciding upon the kind of plant to be adopted. He would certainly always be against either belt or rope-driving for electric installations, because it introduced another link which might go wrong, and it was also a factor of cost. With regard to the efficiency of the various sizes of motors, very small ones under 1 horse-power gave from 50 to 60 per cent., 2 horse-power motors from 79 to 84 per cent., and the larger ones up to 94 per cent. The methods of reducing speeds were, as already indicated, very various. In the case of fans and emery-wheels the motor was applied direct to the axle, without reduction; in other cases by means of shafting; and in others by wheels and pinions, etc. This was also a matter for consideration in each particular case. Mr. Newitt thought the loss in shafting was not very great. He had really answered this point, because naturally if the work was grouped round the steam-engine there was no necessity for electric transmission. It was in cases where there was a certain distance to the farthest point at which power was required that the advantages of electricity were apparent. With regard to the life of the cables, he might remark that they were covered with lead, and some perfectly good lead pipes had been discovered recently which were used in Pompeii, so that he might estimate the life of lead-covered cables not at 18 but at 1,800 years. In reply to Mr. Laverick, they could put in cut-outs to prevent overloading, but they were a terrible nuisance, because they frequently acted when they were not wanted, hence they were generally left out. Mr. Selby Bigge had considered that the information stopped short at the

switch-board; but he (Mr. Siemens) thought he had said quite plainly that the loss in leads at their works was 5 per cent., and the average efficiency of the motors might be taken at 90 per cent. This was not a fancy figure, but represented actual facts. All the figures in the paper were based on very careful observations, and were absolutely reliable. He was obliged to Mr. Morison for having generally endorsed the statements made in the paper, and he hoped that everybody would take his remarks to heart.

Mr. T. Richardson (Hartlepool) wrote that he had read with great interest Mr. Siemens' paper on "Electric Transmission of Power," which would prove of great value and assistance to those who were considering the advisability of introducing electric driving into works. It added to the data which they already possessed, and the remarks and advice of one possessing so much experience must have great weight, and give encouragement to any who were thinking of moving in this direction. It was a move, however, requiring very careful consideration; for whilst it was doubtless one which might be made with every confidence in the case of works where the machinery—being spread over a large area—was dependent on a number of scattered engines for power, it might in the case of small and compact works, where it was not necessary to carry steam any distance, prove to be of little, if any, advantage. In these days, when there are so many opportunities in old-established works for economizing by the introduction of modern tools, any expenditure should be directed into the channel most likely to result in the greatest commercial success, and it was quite possible that a large expenditure might be more advantageously undertaken for new tools rather than for an electric-power plant. They knew that in the case of mines, valuable and economical assistance had been obtained by the use of electrically driven pumps and drills, often where it would have been impossible to utilize steam. Where the work required to be done was situated in workings a considerable distance from the shafts and required immediate treatment, the difference between the time occupied in applying electric motive power as against steam power had often been of considerable gain. In the case of ironstone-mines, where there was an outflow of water from the workings, by adopting a system of storage, it could be utilized for driving a dynamo, and very great economy might be obtained by the adoption of electric driving. The saving of coal in such cases would be large—for the majority of ironstone-mines are situated a considerable distance from the source of their coal-supply. In addition there would be other savings contingent on the application of electric power, which

have been referred to in papers and discussions on the subject. So that, whilst the application of electric driving in mines, etc., has been proved to be capable of adoption with great benefit, in large engine-works much has yet to be developed, and such results as Mr. Siemens had obtained in machine-works are of great value to those who are enquiring into this question. The works with which he (Mr. Richardson) was connected had for some time been carefully looking into this question, and extensive experiments had been made, some of which were recently laid before the members of the North-East Coast Institution of Engineers and Shipbuilders.* Arrangements were gradually being made which would eventually result in steam power being replaced by electric power in the works with which he (Mr. Richardson) was connected.

The PRESIDENT said that he, as he had pointed out in his address, felt the great importance of electric transmission, and he thought that, if they could be satisfied as to the cost of electric transmission compared with other methods, it would be speedily introduced to a greater extent. He then proposed that the hearty thanks of the members be accorded to Mr. Siemens for his paper. Many of the members had recently had an opportunity of passing through the works of the author's firm, and they were now farther indebted to Mr. Siemens for his valuable and interesting paper.

Mr. W. C. BLACKETT seconded the proposal. He was sure that they had all listened with great profit to themselves to that excellent paper, although, as one who had to obtain his livelihood from the coal-trade, he was personally somewhat dismayed by the enormous saving of coal which was to be effected. He hoped, however, that this saving would not take place at once, and that they would have ample time to put their houses in order.

The vote of thanks was carried with acclamation.

The following paper, by Mr. J. Henderson, on "Magnetic Declination in Mines," was taken as read :—

* *Trans.* vol. xi., page 13.

MAGNETIC DECLINATION IN MINES.

By JAMES HENDERSON.

Considerable attention having recently been given by mining engineers and surveyors to the effect of magnetic attraction on the needle of the miner's dial or compass, a few remarks on the subject, chiefly in connexion with the mining district of St. Just in Cornwall, where great local attraction generally prevails, may prove interesting.

The district in question is situated near the western extremity of Cornwall, about 3 miles north of Lands End, and abutting on the precipitous northern coast. It consists chiefly of granite, bounded towards the sea by a comparatively narrow band of hornblende-rock and felspathic "killas" or slate. The line of junction with the granite is irregular, and on either side of it, the mines of the district, now, however, sadly reduced in number, are chiefly situated.

The few mines still at work produce a fair quantity of tin, notably the Levant mine and the celebrated Botallack mine, formerly rich in copper ore, which was raised in the belt of killas already referred to, but whose operations are now confined to the Wheal Cock portion of the sett, which is now being worked for tin.

Adjoining the Botallack mine to the south is Wheal Owles, rendered notorious by the irruption, on January 10th, 1893, of water from an abandoned portion of the workings, and the consequent loss of 20 miners, who were overwhelmed, and whose bodies still remain unrecovered.

The two latter mines, Botallack and Wheal Owles, are selected from the St. Just group for reference, as respectively exemplifying the effect of local attraction and the perennial variation of the magnetic declination.

The Botallack Mine.

In the now abandoned Crown portion of this mine, which extends for a long distance beneath the bed of the Atlantic Ocean, a great amount of local magnetic attraction prevails, rendering compass-bearings quite unreliable.

In order to obtain a correct map of the workings, it was necessary to connect the courses of the different levels with those taken in the long and tortuous diagonal shaft, which was sunk on the underlie from the surface to the bottom of the mine.

The attraction referred to appears to be caused by veins of magnetic iron-ore pervading the mass of felspathic slate, and concentrating in the copper-ore lode and branches on which this part of the mine was worked. From the rapid coating of ferruginous matter over the exposed surface of the levels, it was almost impossible for the surveyor in his periodical visits to detect the minute strings of magnetic ore which might have been affecting the compass-needle, and he had, consequently, to exercise his ingenuity so as to avoid dependence on his bearings for correct results.

In scarcely any mine in the county of Cornwall, except in the instance already given of the Crown portion of the Botallack mine, is there a shaft of sufficient dimensions to allow of a draft-line taken with a theodolite at the surface being transferred to the workings below, as is the case in collieries generally, and therefore recourse must be had to the miner's dial or miner's theodolite, and the polarity of the underground survey must be established by the compass-bearing of at least one of the lines of the intended traverse.

Where no local attraction exists the miner's dial is well adapted to the purpose intended, and as the needle can be thrown off when considered advisable the traverse can be continued on the theodolite principle. But in cases such as at Wheal Cock, in the Botallack mine, where great magnetic attraction prevails, the surveyor has to go, perhaps, nearly $\frac{1}{2}$ mile away, possibly in a cross-cut, into the solid granite in order to ensure a true bearing.

It is a well-known fact that in parts of the Botallack mine the needle has been deflected to the extent of 50 or even 60 degrees from its proper direction, and the utmost care has to be used by the surveyor in consequence.

Thus, in a recent underground survey at Wheal Cock, the surveyor was obliged to seek for a true bearing at a distance of $\frac{1}{4}$ mile from the shaft, and using a draft-line at that place of only 16 feet in length as his base, he carried on the whole of his subsequent survey by means of an angular instrument of recent invention, without reference to any further needle reading. The work involved no less than 363 draft measurements, and occupied seven days in its accomplishment.

Fortunately the shaft at this part was on the underlie from the 160 fathoms level (where the base-line referred to was adopted) downwards, and consequently the traverse was continued from level to level, to the bottom at the 210 fathoms level, without once breaking the connexion established with the starting-point.

Wheal Owles.

The sad catastrophe alluded to in the introductory remarks of this paper, although, no doubt, attributable to the incorrect application of the miner's dial, was found, on investigation, to be due not to the neglect of the surveyor in dealing with local magnetic attraction, which appears in this mine to have been but slight as compared with the Botallack mine, but to ignorance of the perennial variation of the needle which at this part of the county is about 7 minutes easterly per annum.

In the plan of the underground workings, periodically kept up to date with care, the same magnetic meridian was used for a period of forty years.

Thus, the levels of some old workings of great extent and full of water were unfortunately holed by the miners working in a new part, where, by the plan, a safe barrier of solid ground was shown to exist between the old and new portions of the mine.

A very simple method of ascertaining the variation of the compass from the true north line is to take the bearing by compass from any point to any distant object shown on a sheet of an Ordnance map, both ends of this imaginary line being recognizable thereon; then, as these sheets are all drawn with their borders representing true north-and-south and east-and-west lines, the bearing of the line in question can be compared with that given by the compass, and their difference will be the variation from the true meridian and sufficiently accurate for ordinary mine-surveying.

The surveyor who uses the miner's theodolite should bear in mind that his tripod-stands, which in a traverse should be three in number, must be perfectly rigid and free from torsion. If they are not to be depended on in this respect he must adopt the system of reading the compass-bearing of each back and forward observation, for however much such readings may be affected by local attraction the error for the back observation is the same, of course, as for the forward one, and hence the resultant angle (the forward bearing minus the back bearing) is correct.

The use of the compass-needle has in too many cases been condemned. Its misuse, however, is generally the real cause of error. When properly managed it is an instrument of vast importance, and under existing circumstances is, indeed, of actual necessity to surveyors of metalliferous mines.

The following paper, by Mr. R. Russell, on "The Extension of the West Cumberland Coal-field Southward and Northward under the St. Bees Sandstone," was read at the General Meeting, held in Whitehaven on June 21st, 1894* :—

* *Trans.*, vol. vii., page 638.

THE EXTENSION OF THE WEST CUMBERLAND COAL-FIELD SOUTHWARD AND NORTHWARD UNDER THE ST. BEES SANDSTONE.

By R. RUSSELL, C.E., F.G.S.

The exposed portion of the West Cumberland coal-field extends from Barrowmouth along the coast through Whitehaven, Harrington, Workington, and Flimby to Maryport, whence it takes a north-easterly course to Bolton Low Houses. With the exception of a small area between Micklam Point and Salter Beck, where the Lower Coal-measures are brought up to the surface, the whole series of coals are generally present. These coal-seams are well known, and have been largely worked at Whitehaven, Harrington, Workington, St. Helens; Seaton, Clifton, and Camerton in the valley of the river Derwent; Flimby, Ewenrigg, and Ellenborough near Maryport, Dearham, Crosby, Aspatria, and Bolton.

Forming the eastern boundary of the Carboniferous rocks, the limestone extends from Egremont along the west side of the Ehen valley to Yeathouse. Thrown down to the north-east by the Yeathouse fault, it runs through by Stockhow Hall, Kirkland, and Lamplugh to Ullock, thence by Pardshaw and Eaglesfield Crags; crossing the river Derwent between Brigham and Papcastle, it takes a north-easterly course on the north side of the Derwent valley, through Redmain, Blindcrake, and Sunderland Heads to Bothel; thence eastwards by Ireby and Uldale to Caldbeck, whence it ranges south-east through Haltcliffe and Hutton Roof to Greystoke Park.

South of Whitehaven, the Coal-measures are overlain by the Permian rocks forming part of the St. Bees Sandstone series. At Barrowmouth, they are seen resting unconformably on the Whitehaven Sandstone. From the coast, they run up along the side of the cliff and over the ridge at Croft pit, cross the road from Whitehaven to St. Bees at the foot of the Demesne Brow, coming down into the St. Bees valley south of Stanley Pond, and up through Linethwaite wood to the Egremont road. From this point the boundary between the Permian and the Carboniferous rocks is partly a natural and partly a faulted one as far as

Egremont, and probably as far as Grange and Kirk Beck. Thence it passes over Cold Fell, across the river Calder near Prior Scales, along the west side of Ponsonby Fell, into the valley of the river Bleng. Following the south side of this valley, it crosses the river Irt near Irton Hall, winds round into the Mite valley, near Muncaster Mill, and along the base of the fell nearly to Ravenglass. A narrow strip of the Permians extends along the coast south from Ravenglass through Eskmeals, Bootle, and Silecroft to Haverigg Point.

On the north of the Cumberland coal-field, the St. Bees Sandstone is faulted down against the Coal-measures along a very regular line from Maryport, through Crosby, Aspatria, and Brayton, to Bolton Low Houses. Eastwards, as far as the river Caldew, the line is more irregular. Here the Penrith Sandstone first begins to put in an appearance if approached from the west, or disappears if this rock has been followed from the east side of the county.

South of St. Bees, superficial deposits of various kinds cover up the solid rock, but there can be no doubt that the St. Bees Sandstone exists uniformly over the low-lying country along the coast. The height of this tract of country above the sea-level rarely exceeds 200 feet, but there are places where it attains a much higher elevation. Thus at St. Bees Head, the height is 466 feet, at Winscales 440 feet, at Cold Fell 950 feet, near Prior Scales 643 feet, at Ponsonby Fell 731 feet, and at Bleng Fell 800 feet above the sea-level.

In the country north of the Aspatria fault, the Red Sandstone, in one instance only, reaches a height of 400 feet above the sea-level; it rarely exceeds 300 feet, and is more generally about 200 feet above the level of the sea. Viewed from the heights at Moota Hill or Brocklebank Fell, the country stretching away to the Solway Firth appears to be very flat. In reality it consists of a series of undulating ridges and mounds. This particular surface-configuration is due entirely to the deposits of sand, gravel, and boulder clay which cover and obscure the solid rocks on which they rest. Owing to this superficial covering, the solid rocks seldom form any physical features, and the strata are only exposed in the sides and channels of the stream-courses.

It is evident that the red rocks, if they did not originally cover the whole of the exposed coal-field, at any rate covered a very considerable portion of it. In various instances, isolated patches of these rocks, which have been thrown down by faults, are preserved in the form of faulted inliers, enclosed on all sides by faults, or partly by faults and partly by natural boundaries. Thus, St. Bees Sandstone occurs at Ingwell, at

Rheda and Birks near Frizington, and at Yeathouse ; the breccia appears at Keekle, extends from Walkmill to Weddicar Hall, from Millyeat to Frizington, from Yeathouse over the ridge to Arlecdon Moor and Arlecdon Hill, it occurs between the faults at Winder Mines, Parkside Mining Company, on Whillimoor, at Blenket Rigg and south of Dean Moor, and at Gilgarron, near which place a small patch of breccia, composed entirely of large blocks of limestone, lies between two faults.

The Permian rocks, it has been observed, lie upon Coal-measures at Barrowmouth, limestone near Egremont, Lower Silurian slate east of the river Ehen, and finally pass on to the Borrowdale series, extending from Kirk Beck to Muncaster Fell, showing a well-marked unconformity between them and the older formations. Now, it is quite evident that the occurrence of any of the divisions of the St. Bees series is no evidence as to the existence of coal-bearing measures below it, for we have seen that it rests in this locality on rocks ranging from the Upper Coal-measures to the Lower Silurian. In order, therefore, to form an opinion as to the extension southwards of the Whitehaven coal-field under the Permians, we must draw our conclusions from data of quite another character. That the Coal-measures do so extend is a well-known and ascertained fact, but to what distance southwards the coal-field does extend, and whether the coal-seams run out to sea or turn inland, are questions which admit of some speculation.

The workings from the old shafts in the vicinity of Preston Hows were carried under the St. Bees Sandstone. From the Croft pit, the coal has been worked for some distance in the direction of Sandwith, and the base of the red rock proved by boring upward from the underground workings.

Again, at Beckfoot, near St. Bees, Carboniferous rocks have been proved at the depth of 1,125 feet. At Orgill, near Egremont, almost due east of St. Bees, limestone was found under the breccia at the depth of 824 feet ; in the valley south of Egremont, at the depth of 569 feet ; and near Wotobank, at the depth of 1,138 feet. This is the most southerly place at which the nature and character of the strata under the St. Bees Sandstone has been ascertained. Bore-holes have been put down near Braystones and Drigg Cross, but they were not carried to a sufficient depth to prove the thickness of the red rocks.

The foregoing remarks state generally all that is known at the present time in reference to the thickness of the Permians and the classification of the rocks on which they rest in the district between Barrowmouth and Ravenglass. It may therefore be inferred that Carboniferous rocks are

now ascertained to lie under the Permians as far south as Beckermet, but between Beckermet and Ravenglass the ground is altogether unproved.

Near Whicham, the limestone comes to the surface, and the same rock is proved below the Red Sandstone at Haverigg Point. The appearance of the limestone near Whicham, and the knowledge that it underlies the Red Sandstone between Whicham and Haverigg, prove the continuation of the Carboniferous rocks along the coast-line south of Ravenglass. It may therefore reasonably be surmised that in the district between St. Bees and Ravenglass they likewise follow the trend of the general strike of the Carboniferous rocks on the north, and extend under the Red Sandstone nearly as far as the river Esk. Here they are probably thrown westwards, the Eskdale granite running down as far as Hall Waberthwaite.

The inclination of the coal-seams at Whitehaven is towards the west and south of west, and the direction of the dip of the limestone in the neighbourhood of Cleator and Egremont has a similar bearing. Too much dependence, however, cannot be placed on this fact alone when two places several miles apart are to be compared, especially when the information in regard to the district between Egremont and Ravenglass is so meagre as it is at present. But the westerly and south-westerly dip of the Carboniferous rocks generally, and the knowledge that they extend along the base of the Fell district from Egremont north to Cockermouth, and from Cockermouth north-east to Caldbeck, points to the probability of the Carboniferous strata winding round under the St. Bees Sandstone in the district between Egremont and Ravenglass.

Taking the south-westerly direction of the dip as continuous throughout this comparatively unknown district to the south of Egremont, and ignoring faults, which doubtless exist, but of which nothing is known, the strike of the measures would range somewhat in the direction of the thick broken line shown on the map and approximately paralleled to the coast-line (Plate XVI.).

The section (Fig. 3, Plate XVII.) which runs south-east from St. Bees to Muncaster, shows the probable occurrence of the Coal-measures under the Permians between St. Bees, where they have been proved, and the unknown district to the south. Variations in the direction and amount of the inclination of the strata, and the results of faults might have the effect of throwing out the coal-seams altogether, but the changes produced by these causes might have an opposite effect and throw the Coal-measures farther inland, just as the Red Sandstone runs eastward from the coast to Ponsonby Fell. On this section, these two circumstances are supposed in some degree to counteract each other,

and the general run of the coal-seams would consequently be represented by a continuous line, although there would in reality be local changes which could only be ascertained by actual proof. On the plan (Plate XVI.) the probable outcrop of the main band coal-seam is shown by the broken line, and the extreme limit of the Coal-measures by the thick broken line. The probable depth to the Coal-measures would be 1,300 to 1,400 feet.

The Aspatria fault, which runs from Maryport through Aspatria to Bolton Low Houses, brings in the St. Bees Sandstone against the Coal-measures. Its position at the surface can generally be approximately determined. It is hardly likely that there is one great dislocation, but rather a series of downcast faults, the combined effect of which has not yet been actually proved. At Maryport, at Crosby, at Aspatria, and at Bolton Low Houses a fault has been proved, which is evidently the first of the series of downthrows which ultimately bring in the full thickness of the St. Bees Sandstone.

Generally speaking, the inclination of the strata in the Maryport and Aspatria portions of the coal-field is parallel to the direction of the fault, but there are exceptions. At Birkby and Dearham the dip is westerly, but at Crosby it is south-easterly, increasing rapidly northwards. At Brayton it is westerly again, but at Bolton Low Houses, in the space between the Aspatria and Parsonbridge faults, the inclination is towards the north-west.

A dip drift has been driven from No. 1 pit, Crosby colliery, for a distance of about 2,150 feet. In this drift the measures are seen to rise gently to the north-west for 955 feet, and then the inclination increases rapidly northwards to 80 degs. Owing to this north-westerly rise of the strata, the drift cuts through the Lower Coal-measures and finally reaches the top of the limestone, probably on the upcast side of the fault.

The results of the Crosby explorations, and the unusual direction of the inclination of the strata there, are apparently unfavourable to the continuation of the coal-seams under the Red Sandstone on the north side of the fault. Farther, the general westerly dip of the beds is not very encouraging, as the continued existence of the Coal-measures north of the Aspatria fault, unless the direction of the dip changes, would depend on their repetition by faults, as is the case in the exposed coal-field. The bore-holes at Maryport and Allerby are unsatisfactory. They were situated too near to the fault to give results of much value. However, notwithstanding the adverse circumstance above-named, the Brayton main coal has been proved under the St. Bees Sandstone at the new pit

near Brayton station, on the down-cast side of the fault, and about a mile on the north side of the fault. The workings from the new winning will furnish a general notion as to whether any change has taken place in the direction of the inclination or not.

The strata in the district between the Aspatria fault and Bowness occupy a basin. At West Newton and Shalk, the St. Bees Sandstone occurs at the surface, and the same rock has been proved under the surface-drift at Bowness. This basin-shaped area is likely to be traversed by faults, notably the continuation south-westward of the Cummersdale faults, and the extension northward of the Westward Cottage and Parsonbridge faults. The central portion of the district is occupied by Lower Lias, Keuper marls, and Bunter sandstone. From Great Orton on the south to Kirkhampton on the north, and from Aikton on the west to the river Eden on the east, the Lower Lias occurs in the centre of the basin. North of Carlisle, the Keuper marls overlying the Kirklinton sandstone are very thin. At Lyneside, the marls are not present, but under 36 feet of sand and clay the Kirklinton sandstone was found, and the St. Bees Sandstone at a depth of 95 feet, proving the continuation of the syncline in a north-westerly direction.

On the south-west of the river Eden, the Lower Lias is most probably thrown down against the marls, because in the district about Abbey Town the marls are proved to be much thicker than they are at Carlisle. At Kelsick Moss under clay, sand, and gravel 198 feet 6 inches thick, 945 feet of Keuper marls were proved. Under the marls was a grey sandstone resembling the grey sandstone in the river Eden near Cargo, and below the grey sandstone a soft red sandstone, but whether Kirklinton or St. Bees Sandstone it was difficult to determine from the samples.

Practically, within the whole of the basin from the Aspatria fault to the Solway Firth the character of the rocks underlying the St. Bees Sandstone is almost unknown, except that coal has been proved under it at Brayton. After giving due consideration to the adverse circumstances of the general inclination of the known coal-field, and the particularly unfavourable nature of the exploring drift at Crosby colliery, it is difficult to conceive of the entire removal of the Coal-measures from this syncline before the deposition of the St. Bees Sandstone. It is more natural to conclude that within the syncline between Wigton and Bowness the coal-bearing strata were not denuded prior to the time when the St. Bees Sandstone began to be formed, and that a coal-field of greater or less extent was left in this district and covered over by the newer formations, and thus preserved from all farther denudation. In the area between the extension

northwards of the Parsonbridge fault and the river Eden, the Carboniferous rocks will lie at a great depth, because in this locality the full thickness of the Keuper marls and of the St. Bees Sandstone will have to be passed through before they are reached, but at Carlisle the thickness of the overlying rocks will probably not exceed 1,500 or 1,600 feet, and along the coast north of Allonby their thickness may not be more than 1,300 or 1,400 feet.

Reviewing the whole of the evidence which at present exists, the probability is, that the Cumberland coal-field of the future will extend from Whitehaven southwards to Drigg, with a breadth inland, south of St. Bees, of from 1 to $1\frac{1}{2}$ miles, and seaward to an unknown distance, probably several miles. With reference to the probable northern extension of the coal-field between Maryport and Waverton on the south and Skinburness on the north, it will possibly lie at a moderate depth, and extend westwards for some distance under the Solway Firth. Within the faulted basin between Abbey Town and Kirk Andrews-upon-Eden the seams will lie at the greatest depth, perhaps not less than 2,400 feet. At and north-eastwards from Carlisle, the Carboniferous rocks, as already stated, may be reached at from 1,500 to 1,600 feet, but whether these rocks in the neighbourhood of Carlisle will contain workable coal-seams or not, yet remains for the boring-machine to prove.

Mr. W. Fletcher (Carlisle) asked if the author was of opinion that the New Brayton pit was on the north side of the Crosby fault?

Mr. Russell said he understood that to be so.

Mr. W. Fletcher said he was reluctant to differ from so high an authority, but his own opinion was that the fault on the north side of which that pit was situated was a trifling branch from the main fault which ran up the valley of the Ehen, and had been proved at No. 3 pit, Brayton colliery. He thought that the Crosby fault would be found on the north-west side of the New Brayton pit.

Mr. R. P. W. Oswald (H.M. Inspector of Mines, Whitehaven) thought the No. 4 pit, Brayton colliery, was on the upcast side of the fault, and that they had not yet proved the main fault.

Mr. J. D. Kendall (Whitehaven) said that he had nothing to add to what he said in 1883, when he read his paper "On the Structure of the Cumberland Coal-field" *—at all events not with regard to that portion north of Maryport; there was still a good deal to be done by either the sinker or borer in that area before any definite opinion could be formed.

* *Trans. N. E. Inst.*, vol. xxxii., page 319.

From a geological point of view it was a mere matter of speculation. The same remark applied to the area south of Egremont, but he might point out one or two facts, which he thought were not noticed in the paper, with reference to the band of Carboniferous Limestone between Rowrah and Bigrigg. The trend of that rock was to the south-west, which was pretty much the trend of the Coal-measures too. Now, the distance between Rowrah and Bigrigg was 5 miles, and the net aggregate throw of the faults up west was 5,700 feet between these points. It was stated in the paper that the probabilities were that the coal-field would be found extending inland about $1\frac{1}{2}$ miles from St. Bees. Now, at Bigrigg, which is only 2 miles from St. Bees, they had the top of the limestone at the surface; and bearing in mind the number of faults crossing that band of limestone, and which are all up to the west, between Rowrah and Bigrigg, he thought it extremely likely that they had not yet found the last of those faults, and that there were others hidden underneath the Red Sandstone. He thought it extremely likely that if these faults were repeated under the Red Sandstone, they would find the Coal-measures much farther seaward than Mr. Russell expected. Again there was a large east-and-west fault passing through the Cleator Moor coal-field near to Mr. Stirling's No. 4 pit, and a continuation of that fault would strike the coast a little south of St. Bees Head. Now, the throw of that fault was about 1,200 feet up to the south, and he thought it was very likely that the fault would continue to the coast, and have a very serious effect on the southern continuation of the coal-field.

Mr. R. W. Moore said, as regards the coal-field south of St. Bees Head, in 1890, when it was said that coal had been discovered at Bootle, he ascertained that the report was due to some pieces of coal and shale having been found in some shallow holes that had been dug on an estate, called Hyce Moor Side, north-west of Bootle railway-station. The owner of that estate also told him that in cutting a drain he cut a spring some six years previously, and after the water had drained off a lot of small coal had come away. These were the slender bases upon which the report was formed, and it still remained for a deep bore-hole to be put down to show that the coal-field extended so far southward. He agreed with Mr. Oswald that the main fault had not yet been reached on the north at Brayton colliery.

Mr. Watkyn Thomas (Cockermouth) asked what was Mr. Russell's explanation of the fact that, if—as he understood him to assume—the Brayton seam in the new pit was on the north or downthrow side of the fault, there was no difference in depth between the No. 3 pit (on the

south side) and No. 4 pit (on the north side), as the two seams were practically on the same level? If the fault that crossed that district was supposed to be a big fault, these facts seemed at once to prove that the No. 4 pit was on the upthrow and not on the downthrow side of the fault.

Mr. W. Peile (Whitehaven) said with regard to the probable extension of the coal-field south of Whitehaven, it had always appeared probable to him that the coal-field might extend farther out to sea than Mr. Russell had indicated, and that it might connect with the North Wales coal-field.

Mr. R. Russell said the only question which appeared to him to be of particular moment was with reference to the fault at Brayton. He considered that it was probably not one great fault but a series of faults, and that the fault met with at Brayton, and that on which the No. 4 pit was sunk, was the first of a series of faults which resulted in the whole thickness of the St. Bees Red Sandstone being thrown in. No doubt there was a fault on the south side of the downcast to which he referred; a fault had been proved at Aspatria and also at No. 3 pit, Brayton colliery, in consequence of the exploration made on the north side of the fault. The same fault had been proved at the collieries at Maryport, where the St. Bees Sandstone was thrown down. The main point which concerned the existence or non-existence of the fault was the extremely unfavourable position of the Coal-measures about Crosby.

Mr. Watkyn Thomas (Cockermouth) thought there was one other point of interest. At the Aspatria collieries, the Coal-measures rose eastwards, and at All-Hallows colliery, at a distance eastwards of about 3 miles, the two collieries were on nearly the same level from the surface; so that there must be either a big fault or a series of faults, because the measures dip westwards on an average about 6 inches per yard. Had Mr. Russell any notion of where the fault or faults came in that brought about such changes between these two collieries?

Mr. Russell said there was a parallel series of north-and-south faults crossing the coal-field, the outcrops being repeated again and again.

The President proposed a vote of thanks to Mr. Russell for his excellent paper.

Mr. G. B. Forster seconded the vote of thanks. The subject, which was one of considerable importance, required more thought than a first reading of the paper, and as the discussion would be adjourned he hoped the members would study the printed paper and then give the Institute the advantage of their views.

The vote of thanks was cordially adopted.

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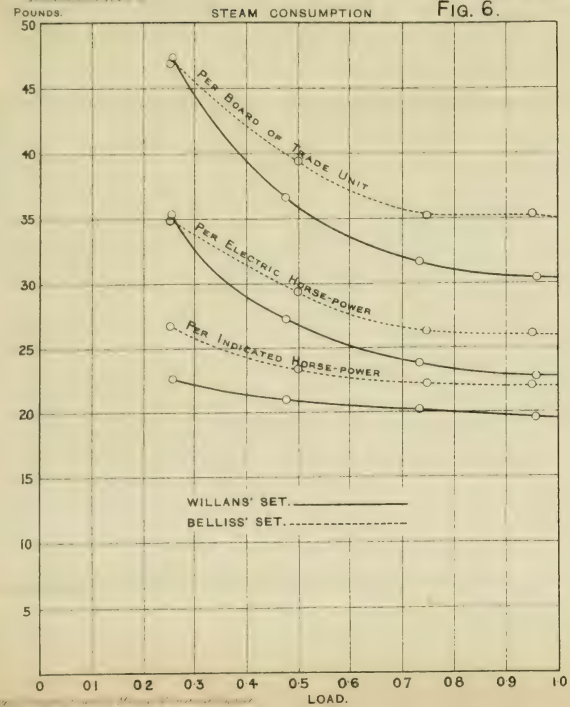
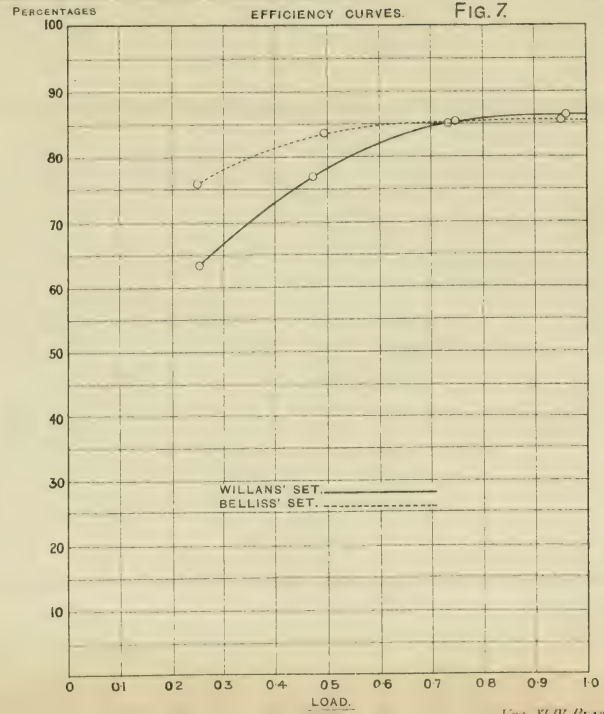

POUNDS.
STEAM CONSUMPTION
FIG. 6.
50
45
40
35
30
25
20
15
10
5
PER BOARD OF TRADE UNIT
PER ELECTRIC HORSE-POWER
PER INDICATED HORSE-POWER
WILLANS' SET.
BELLISS' SET.
0 01 02 03 04 05 06 07 08 09 10
LOAD.


PERCENTAGES
EFFICIENCY CURVES.
FIG. 7.
100
90
80
70
60
50
40
30
20
10
WILLANS' SET.
BELLISS' SET.
0 01 02 03 04 05 06 07 08 09 10
LOAD.

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To illustrate Mr R. Russell's Paper on "The Extension of the West Cumberland Coal-field Southward & Northward under the St. Bees' Sandstone."

FIG. 2.—SECTION SHEWING THE UNCONFORMITY BETWEEN THE ST. BEES' SANDSTONE AND THE CARBONIFEROUS AND SILURIAN ROCKS IN THE DISTRICT FROM ST. BEES HEAD TO MUNCASTER FELL.

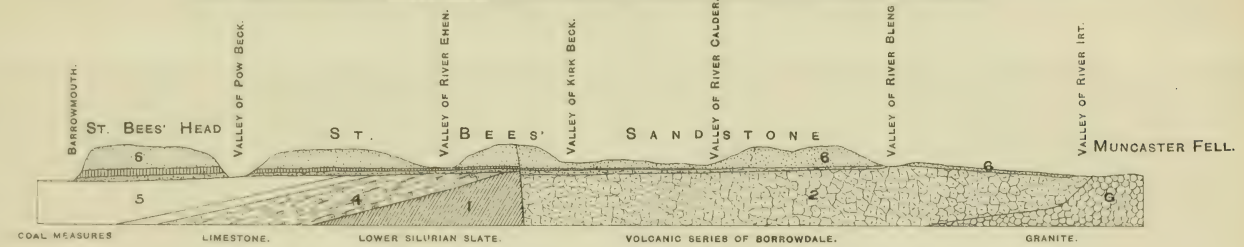
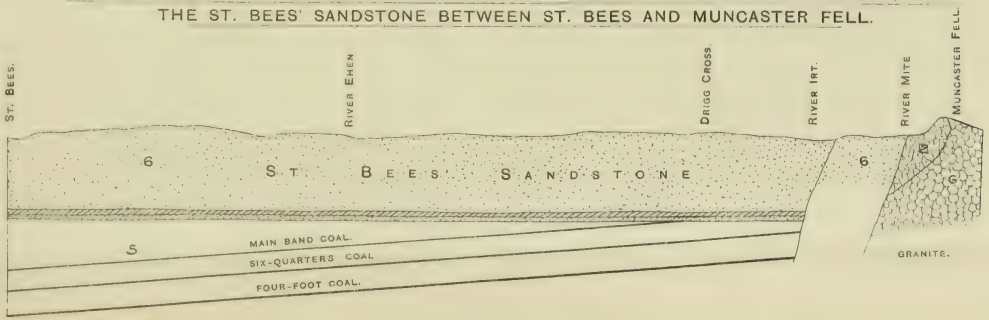


FIG. 3.—SECTION SHEWING THE PROBABLE EXTENSION OF THE COAL-MEASURES UNDER THE ST. BEES' SANDSTONE BETWEEN ST. BEES AND MUNCASTER FELL.



THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

JANUARY 19TH, 1895.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council of that day.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Rev. HENRY PALIN GURNEY, Principal of the Durham College of Science, Newcastle-upon-Tyne.

MEMBERS—

Mr. BASIL JOHN ATTERBURY, Mining Engineer, 18, Eldon Street, London, E.C.

Mr. WILLIAM BIBBY, Manager of the Raub Australian Gold Mining Co., Limited, Raub, Pahang, Malay Peninsula.

Mr. HARRIS BIGG-WITHER, General Manager of the Roburite Explosives Co., Limited, 10, Swinley Road, Wigan, Lancashire.

Mr. GEORGE BOOLE, Mining Engineer and Colliery Manager, Rainford, near St. Helens, Lancashire.

Mr. HENRY HUNTER CAMPBELL, Land and Mine Surveyor, and Mining Engineer, Sutton Hall, St. Helens, Lancashire.

Mr. JOHN FLINT, Colliery Manager, Broomhill Colliery, Acklington, Northumberland.

Mr. WILLIAM KENNEDY, Geologist and Mining Engineer, Austin, Texas, United States of America.

Mr. LLOYD WILSON, Colliery Managing Director and Engineer, Flimby Colliery, Maryport.

ASSOCIATE MEMBERS—

Mr. JOHN S. BOLTON, Electrical Engineer, 78, Brighton Grove, Newcastle-upon-Tyne.

Sir GEORGE WILLIAM ELLIOT, Bart., M.P., 16, Great George Street, Westminster, London, S.W.

Mr. GEORGE B. SAUNDERS, Chemical Agent, etc., c/o Messrs. Dawson, Saunders, & Todd, Maritime Buildings, Newcastle-upon-Tyne.

STUDENTS—

Mr. HENRY DUNFORD COWAN, Mining Student, Elswick Collieries, Newcastle-upon-Tyne.

Mr. JAMES BERTRAM SAMPLE, Mining Student, South Tanfield Colliery, Stanley, R.S.O., County Durham.

———

The following gentlemen were nominated for election :—

MEMBERS—

Mr. ALEXANDER AGASSIZ, Mining Engineer, Museum of Comparative Zoology, Cambridge, Massachussetts, United States of America.

Mr. THOMAS BATES, Colliery Manager, The Grange, Prudhoe-upon-Tyne.

Mr. ROBERT GILMAN BROWN, Mining Engineer, Box 946, Butte, Montana, United States of America.

Mr. WILLIAM CLIFFORD, Mining Engineer, Pittsburgh, Pennsylvania, United States of America.

Mr. JOHN S. CRAWFORD, Consulting Engineer, Kingston, Sierra County, New Mexico, United States of America.

Mr. JOHN HENRY DARBY, Steel Manufacturer and Engineer, Pen-y-Garth, Brymbo, Denbighshire.

Mr. DAVID EVAN DAVIES, Colliery Manager, Cwmaman Colliery, Aberdare.

Mr. THOMAS INGLEBY DYSON, Metallurgist, Mount Morgan, Queensland.

Mr. EDWARD EDWARDS, Colliery Manager, Maindy Pit, Ocean Coal Company, Ton Pentre, South Wales.

Mr. G. GRAVES GIFFORD, Mining Engineer, Perth, Western Australia.

Mr. GEORGE ERNEST GREGSON, Land Agent, Land and Mine Surveyor, 11, Chapel Street, Preston.

Mr. JOSEPH HADFIELD, Colliery Manager, Hulton Collieries, Chequerbent, Bolton, Lancashire.

Mr. DAVID HANNAH, Mining Engineer, Brynderwen, Ferndale, South Wales.

Mr. C. D. SULLIVAN, Mining Engineer, Bonang, Delegate, New South Wales.

Mr. JESSE WALLWORK, Assistant Mining Engineer, Haydock Collieries, near St. Helens, Lancashire.

ASSOCIATE MEMBER—

Mr. GEORGE BENEKÉ, Managing Director of an Explosives Manufacturing Company, 70, Gracechurch Street, London, E.C.

ASSOCIATE—

Mr. JOHN RIVERS, Master Shifter, Front Street, Tudhoe Colliery, County Durham.

STUDENT—

Mr. HENRY SCOTT STRATTON, Mining Student, Cramlington Collieries, Northumberland.

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DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

Mr. W. C. Blackett, as a suggestion, enquired whether the Explosives Committee, being satisfied that there was as yet no "flameless explosive" would not be justified in changing the name from that of "Flameless Explosives Committee" to some other name which would be more truly descriptive. The *Report*† stated that owing to the contradictory results of many previous experiments, it was desirable to clear away doubts and uncertainties in the employment of safety-explosives, and even if this object had not been entirely effected, the experiments of the committee have advanced the general knowledge of the subject. The first doubt, however, which occurred to him (Mr. Blackett) was as to the practical value of the experiments, owing to the fact that the conditions usually obtaining in a mine have not been obtained in the apparatus used: for example, the use of the varnished brown-paper diaphragm. He was not going to say that similar conditions were never approximately produced in a mine, but they ought not to be; and any one firing a shot under such conditions would be acting as wrongly as though he permitted the use of an imperfect safety-lamp. Under ordinary conditions, such a state of circumstances did not exist; and they were at once met with the question, as to whether and how this diaphragm affected the inflammation of the contained gases. He (Mr. Blackett) was of opinion that confinement might increase the explosive violence of the gases; that the firing of a shot might produce a state of compression of the gases before the diaphragm was fractured; and that this state of compression might produce a readier ignition, and would lower the temperature at which the ignition could take place. Would the gaseous mixtures therefore have been as readily ignited had their movement been less restricted? The means for reasoning in some parts of the *Report* was somewhat insecure; for instance, in the pit-gas experiments, no ignitions were recorded in twenty-five shots of bellite, while with securite, one ignition took place in the only shot fired.‡ Apart from the perhaps far-fetched casual doubt that, had one more shot of bellite been fired an ignition might have been got, and had

* *Trans. Fed. Inst.*, vol. viii., page 227. † *Report*, page 5. ‡ *Ibid.*, page 19.

twenty-five more shots been fired of securite there might have been no more ignitions; the conclusion is, that bellite is safer than securite. Now, apply the same line of reasoning to the experiments with carbonite:* out of eight experiments in 10 per cent. of coal-gas and with 1 inch of stemming only one ignition was obtained; but in one experiment in 10 per cent. of coal-gas with $6\frac{3}{4}$ inches of stemming there was one ignition. According to the reasoning used in the first instance, they ought to conclude, in the case of carbonite, that 1 inch of stemming was safer than $6\frac{3}{4}$ inches. It may be observed, that if the members had had no practical experience of the working of explosives in collieries, and did not know that "when blasting in coal or stone, the length of stemming is of greater importance"† they would have concluded from the experiments "that no substantial degree of safety is attained by the extra length of stemming used"‡ This statement is a farther illustration of the danger of trusting to experiments, which do not closely follow the actual conditions of a mine. The stemming used was "damp puddled clay"§ and unless the consistency were the same in all the experiments, the comparisons are worthless. A small excess of water, in a long length of stemming, would make it offer less resistance than a shorter length of the same clay well rammed and in a dryer state. He (Mr. Blackett) decidedly differed from the committee and ventured to affirm that a substantial degree of safety was obtained by extra length of stemming. It was admitted by the committee that the weights of the shots used do "not represent the relative strengths of the several explosives when fired confined."‖ From this statement it may be inferred that except in the case of unstemmed shots,¶ it is useless to endeavour to compare any of the explosives. Nevertheless, the committee proceed to make such comparison, saying "under conditions of stemming, however, for the sake of uniformity, comparative experiments were also made with the weights of the several explosives" as given in the table of strengths.** Referring, however, to the indisputed permission given for comparison of the various explosives when fired unstemmed, he greatly doubted whether there was any mode of ascertaining the relative strengths of explosives, so as to obtain the comparative actual effects in practical use in mines; in other words, it was very questionable whether the figures recorded by the committee as representing the relative strengths of the explosives did represent their actual mining strengths. It seemed to

* *Report*, page 34. † *Ibid.*, page 32. ‡ *Ibid.*, page 31. § *Ibid.*, page 31.
‖ *Ibid.*, page 18. ¶ *Ibid.*, page 17. ** *Ibid.*, page 18.

him that the Trauzl method ignored a very important factor, and that was the time or duration of the explosion. The rapidity of the impact of the high explosive is such that, in the case, say of coal, it vents much of its force in crushing to powder those parts which immediately surround it, and much more explosive is required to do the necessary work than would be the case were the force distributed over a longer period of time. Gunpowder has a great advantage in this respect, since its work is spread over a longer time, and its time of contact is greater. There is the same kind of difference in the use of a wooden mallet and a steel hammer. The Trauzl method does not take this difference of action of explosives into account, and Table I.* would lead one to suppose that it would be necessary to use 25 ounces of powder in order to get the equivalent strength of 1 ounce of bellite; consequently the table is quite valueless from a practical point of view. The *Report* says that the explosives considered are probably not used for the purpose of getting coal. It is a fact, however, that a few collieries do use such explosives for getting coal, and it was recently ascertained that sixteen collieries in the county of Durham were using high explosives for coal-getting. The next doubt which he (Mr. Blackett) had was as to flame. Flame is a somewhat indefinite term applied to a phenomenon of heat and light. One human sense discovers the first and another the latter, but no one sense can receive both impacts; consequently it is questionable whether the human eye is a sufficiently reliable organ for the purpose of testing phenomena, the temperatures of which are the most important features, yet the eye is what the members of the committee have used in their observations. They have not attempted to observe the actual temperatures, but have relied solely upon the effect of flashes of light upon the eyes of various persons. The difficulty of recognizing by this means what was actual flame and what was light is mentioned in the *Report*,† together with the somewhat curious conclusion that such observations could only be reliable if made in daylight. The reason for this opinion may possibly be found in the fatigue of the retina of the eye (induced by the more powerful daylight) whereby it becomes to some extent insensible to weaker light, and exemplifies one of the defects of the eye as an optical instrument. Not only were the committee satisfied with the eye for this purpose, but it is apparently assumed that all eyes could observe alike. This reasoning is obviously unsound, as one eye will see rays of light to which another is absolutely blind. No tests for eyesight are mentioned in the *Report*, and the difference of observers' powers in this respect

* *Report*, page 17. † *Ibid.*, page 22.

probably accounts for such an instance as, say, that which is noted in experiment No. 8, of June 30th, 1893, where flame is observed in the first five sight-holes, not observed at No. 6, but seen again at No. 8. Was there flame at No. 6 sight-hole? If not, then how could it be seen at No. 8? The suspicion, one naturally arrives at, is that either a flash of light was there, and could not be seen at No. 6, or it was not there, and the observer at No. 8 sight-hole imagined that he saw it. On what grounds, too, did the committee differentiate their observations so as to call what was seen in the case of explosives "flame," and in the case of detonators "flash?" The question that occurred to one, on looking through Table VI. of experiments with detonators * showing that the detonator alone may cause the ignition of gas, was, how are we to know whether it was the explosive used or its detonator which caused certain of the ignitions that took place with unstemmed shots?† The *Report* quoted the experiments of the French Commission to the effect that "detonators containing from 23 to 31 grains of fulminate of mercury did not ignite mixtures of fire-damp,"‡ and goes on to say that the committee's experiments are not in accord therewith, inasmuch as "mixtures of both coal-gas and air and fire-damp and air have been ignited by detonators containing 15·4 grains of fulminate of mercury."§ A reference to the Report of the French Commission proved that a deficient quotation had been made. The French Commission state that plugged detonators with 23 and even 31 grains of fulminate did not ignite fire-damp, and that unplugged detonators with 23 grains of fulminate had ignited gaseous mixtures.‖ The committee make no distinction between plugged and unplugged detonators, and from their description in the *Report* it was to be inferred that unplugged detonators were used.¶ The conclusion that fire-damp was more easily ignited by detonators than coal-gas, would have been more convincing had an equal number of shots been fired in each gas.** It is gratifying to find that the committee's conclusions—Nos. 1, 4, and 5††—are practically in accord with those of the French Commission.‡‡ It is probably indisputable that some of the safety-explosives have as much right to the prefix "safety" as safety-lamps, and the experiments of the committee appear to prove that when properly stemmed

* *Report*, page 27. † *Ibid.*, page 23. ‡ *Ibid.*, page 26. § *Ibid.*, page 27.

‖ *Report of the French Commission on the Use of Explosives, etc.* Translation by Messrs. W. J. Bird and M. Walton Brown, 1891, pages 40 and 41.

¶ *Report*, page 28. ** *Ibid.*, page 29. †† *Ibid.*, pages 40 and 41.

‡‡ *Report of the French Commission, etc.*, translation, page 43.

they are incapable of igniting fire-damp. Nothing more could be said of a safety-lamp, if properly handled it could not ignite fire-damp. If, therefore, in the hands of one workman the two articles are equally safe, the position of the safety-explosive is the better as regards gas, since, where only picked workmen are allowed to handle an explosive, all workpeople are allowed to carry safety-lamps. The second conclusion must be true, that perfect mixing of the ingredients of an explosive is important. He, however, would like to know upon what evidence the committee based the conclusion that the variable results of the experiments with the explosives were due to their defective admixture. This appears to be more of a conjecture than a conclusion, and manifestly, if it could be alleged against any explosive, it might equally apply to detonators, gas mixtures, etc. The third conclusion, as to careful storage, is well known, although it may not be carried out by all users of safety-explosives. The sixth and seventh conclusions have, to some extent, been qualified by the speaker's remarks as to flame. It did not appear to him that the smooth bore of a cannon and a plug of wet clay were fair representatives of a stone borehole and its stemming; and he was disposed to question whether such mobile substances as wet clay or water were as safe as the usual slightly damp borings of stone, which tend to set in the borehole and into its rough sides; and farther, he thought that, were the stemming increased so as to sufficiently increase the work to be done in dislodging it, even in the case of a cannon, it would be found that the emission of heat would be insufficient to fire an explosive mixture of coal-gas and air. He (Mr. Blackett) had made some experiments with stemming in an iron pipe (1 inch in diameter), and had measured the force required to dislodge well-rammed stemming. He obtained the results tabulated below:—

Description.	Stemming. Length in Inches.	Force required in lbs.
Damp puddled clay	6 ...	56
,, ...	12 ...	80
Damp seggar boring	2 ...	56
,, ,, ...	4 ...	336
,, ,, ...	6 ...	1,232

Had the committee, therefore, used seggar-borings instead of clay, it was only reasonably to suppose that the results would have been more satisfactory. The committee's experiments warn miners against the danger of blown-out shots, and therefore against using a greater weight of explosive than is necessary to do the work required; and, as manifestly, a workman who had already charged a hole would have used fully as much explosive as he judged to be sufficient, it would be objectionable for more

to be added, as alluded to in the eighth conclusion. He would therefore suggest, for the committee's consideration, the advisability of adding to the eighth conclusion the words—"but in view of the possible danger from over-charged shots this practice is not to be recommended."

Mr. J. L. Hedley (H.M. Inspector of Mines) asked Mr. Blackett to describe how he made his experiments upon stemming ?

Mr. Blackett said he first placed an iron pipe (about 1 inch in diameter) on a hard surface, rammed in the clay with a piece of wood to the required length, and fixed the iron pipe into a machine (used for measuring the breaking-strain of wire-ropes). He was then able to apply pressure and to measure the force employed when the clay began to protrude. All the borings were similarly well-rammed with a wooden stemmer, and in all cases the readings of the dial were taken as soon as the stemming began to move.

Mr. D. A. Louis (London) asked whether any analyses had been made of the atmosphere in the tube after an explosion, for if even mixed with external air, so as to upset the proportions, nevertheless the character of the products of explosion under the existing conditions could be ascertained, and it would be interesting if only to compare them with the results of previous investigations of the same description ?

Mr. Beneké wrote that he was convinced that the committee had arrived at wrong conclusions with regard to the length of flames emitted by the various high explosives. According to Table IV.* bellite, securite, ammonite, roburite, carbonite, and ardeer powder were supposed to have produced flames varying in length from 10 to 36 feet, when fired unstemmed into air only. He maintained that such flames were impossible ; the instantaneous flash-light from a shot fired in total darkness, through a long tube, with small sight-holes for observation, conveyed to many an unaccustomed eye the impression of enormous flames. This, however, was not so ; reflection only was seen, as proved by hundreds of photographs taken of the length of flames produced by many high explosives. The actual flames were very short, often not more than 1 or 2 inches long, and it depended entirely upon the composition of the explosive, as well as upon the temperature of the flame, whether such short flames would cause an ignition of the gaseous mixture or of coal-dust. Again, in Table IV., flames from 10 to 62 feet long were supposed to have been seen when the shots were fired into mixtures of 4, 6, 8, and 10 per cent of coal-gas, and without igniting the inflammable mixture. The supposed flames could only have been reflection, as 6 or 8 per cent. of coal-gas could easily be

* *Report*, page 23.

ignited with an ordinary match, and certainly more readily by such enormous lengths of flames as those presumed to have been observed. In the mine, shots weighing from 6 to 16 ounces of explosives were usually employed, yet many of the committee's experiments were made with 1 to $1\frac{1}{4}$ ounces shots, exploded with a powerful detonator, which was only intended for use with much larger quantities. Consequently, many ignitions were recorded which could only be attributed to the powerful detonator, which increased the available amount of oxygen and generated more heat and a larger flame. It was impossible, therefore, to regard the results obtained as final or satisfactory.

Mr. F. Berkley said he did not consider that Mr. Blackett's experiments with stemming were applicable to the discussion, as he thought that stemming, which would resist sufficiently the force of an explosion, might show very little resistance to a steady push with a rammer. With dynamite, they all knew that, where it was applicable, water was a sufficient stemming, and, in the case of water, there would be no resistance to the rammer.

Mr. Larsen said that if the experiments with explosives fired in the Trauzl cylinder were considered, it would be found that gunpowder fired by a detonator had less strength (36) than an equal volume of dry sand, surrounding a detonator alone (46).* The use of the Trauzl cylinder was very well known abroad, and it had never been regarded as a reliable means of testing the relative strength of explosives with different velocities of combustion. Its results had, however, been used as the standard of strength by the committee. On referring to the *Report*, he found that the charges of ardeer powder and carbonite used were from twice to nearly four times respectively the weight of those of bellite, securite, and roburite.† A weight of $3\frac{3}{4}$ ounces could not by any means be considered a severe test, but it was a comparatively severer one than that to which the other explosives were submitted. There were many engineers who had to daily deal with these explosives, and he thought their judgment as to their relative strengths would be much more valuable than the mortar test or the Trauzl cylinder; they would be able to state which was the strongest and how much stronger one explosive was than another. They would agree that most of the safety-explosives, which were used to a great extent in coal (at any rate in South Wales and Lancashire, if not so much in Durham and Northumberland), might be taken as interchangeable, and cartridges of one kind used in substitution for those of the same weight of another kind. He would therefore

* *Report*, page 17. † *Ibid.*, page 17.

suggest that the same weight of explosive should be used in the farther experiments and in much larger charges than had been used hitherto. By gradually increasing the charges, the limit of safety could thus be determined for each explosive. Similar experiments had been made on the Continent with charges as high as 16 ounces, without any stemming. Such charges, of course, gave a very heavy shock, and he understood that the committee did not care to incur the danger of bursting the cannon. This danger, of course, was a serious objection, but the cost of a new cannon should not be allowed to prevent heavy charges of explosives from being tested. With regard to the observations of flash and flame, he concurred in Mr. Blackett's remarks. The committee had stationed gentlemen, each at their particular window, to make observations independent of the others. No doubt this was a very good idea, but to show how easy it was to err in this matter, he might mention that in experiments which he had recently witnessed, twelve or fifteen people were looking at one place, and about half of them saw the flame and the other half did not. He was inclined to believe that there was very little difference in the actual composition of the explosives. The explosives were sampled from time to time by the Government inspectors and submitted to analysis in London, and any deviation from the terms of their manufacturing or importing licenses would render the licensees liable to penalties.

Mr. Thomas Bell (H.M. Inspector of Mines) asked if he understood the last speaker aright that 16 ounces of explosives were fired without stemming, and, if so, with what object?

Mr. Larsen said that such severe tests had been made: it being considered that an explosive which would bear an abnormally severe test would be safe under less severe conditions.

Mr. Thomas Bell, referring to Mr. Larsen's remarks upon the observation of flame, said he understood that gentleman to say that there was only one pair of eyes to make each observation, but in the case of the committee's experiments there was a fresh set of observers every day, and before the experiments with one class of explosive were concluded possibly fifty pairs of eyes might have been employed to observe the results.

Mr. Larsen said he did not wish to make too much of this point, but simply to endorse Mr. Blackett's remark that there was a difficulty in recognizing what was seen.

Mr. R. W. Berkley said that the results of the experiments of the French Commission showed that the greater the quantity of explosive

used the greater the danger. The Explosives Committee of the Institute seemed to have used rather small quantities, would it not be desirable in future experiments to use heavier charges? The pit-gas used in the experiments contained 18 or 19 per cent. of nitrogen. How did this compare with ordinary pit-gas?

Mr. Saville Shaw said that the pit-gas used in the experiments contained 18 or 19 per cent. of nitrogen, and Mr. R. W. Berkley suggested that this gas might have perhaps some effect on the temperature of ignition. That point had, however, been settled by Messrs. Mallard and Le Chatelier,* who proved that an admixture of an indifferent gas, such as nitrogen, had not the slightest effect in altering the temperature of ignition of mixtures of pit-gas and oxygen; that pit-gas and oxygen had a definite temperature of ignition, and that the gaseous mixture could be diluted with an inert gas like nitrogen, and the dilution would not have the slightest effect upon the temperature of ignition.

Mr. J. L. Hedley (H.M. Inspector of Mines), in reply to Mr. Blackett, said that it was necessary to have a diaphragm in order to confine the gases to a certain portion of the tube; they could not divide the explosive chamber from the remainder of the tube in any other way. The paper-diaphragms were used in all the experiments when gas was required, and whatever objection there might be to the use of these diaphragms would apply equally in all cases. Mr. Blackett had referred to the wet stemming, but the stemming used in the experiments was not wet, it was "damp, puddled clay," not quite dry, but well-tempered, and before being put into the bore of the cannon, it had generally been surrounded with some dry clay to enable them to press the charge properly into the mouth of the cannon. He did not think that the steady pressure used in the experiments made by Mr. Blackett could be compared with the results obtained by a sudden and violent explosion. In the case of gunpowder, a suitable length of stemming must be used, but with high explosives a shorter length of stemming was sufficient. The experiments had proved that the difference (so far as safety from flame was concerned) between 2 inches and 8 inches of stemming was very little; and practical experience in the mine had also proved, time after time, that high explosives required much shorter lengths of stemming than gunpowder. Many comments had been made, in that hall and elsewhere, as to the small charges of explosives used in the experiments. He thought that when the weight of 8 ounces of gunpowder was first decided upon as a basis, it was because shots of that size were

* *Annales des Mines*, 1883, vol. iv., page 295.

used in this mining district. If that quantity of gunpowder were used, it was proper therefore when higher explosives took its place to make the experiments with the equivalent weights of each. He could not say whether different results would be obtained with heavier weights of explosives, for the committee had not a cannon suitable for that purpose at present. The observation of flame was a matter which the committee had considered of great importance, and the members of the committee had now had considerable experience. Although it was quite possible that anyone seeing a reflection for the first time, and, consequently, with an unaccustomed eye, might mistake it for a flame, he thought their experience qualified them to judge whether they saw flame or reflection, and so far as they had been able to prove they were far better able to distinguish between the two in the daytime than at night, for reflection could be seen very much farther in the dark. So far, however, as that part of the experiments was concerned, the committee were compelled to trust to their eyesight, for they had no other means of observation. They had done the best that they could, and he thought it could be safely said that the results recorded were thoroughly reliable. It was stated in the *Report* that the explosives might be defective, and Mr. Blackett suggested that the detonators might also be defective. That might be the case, but they were certainly justified in saying that the manufacture of explosives might be defective, from the varying results obtained. It was known and admitted by manufacturers that variations did occur in the composition of an explosive which might materially affect its action. Samples were therefore taken of each batch before placing it on the market, and, if found defective, it was condemned. A small quantity, however, could only be tested, and it was quite possible that some portion of the bulk might be inferior and the remainder good; yet the inferior portions might escape detection until it was brought into actual use belowground. He took issue at once with Mr. Blackett as to the defective mixture of the gases; such a defective mixture had not been found, and this statement was proved by the fact that when a gaseous mixture was not exploded by the shot itself it was immediately afterwards exploded by means of a match. Mr. Louis enquired as to analysis of the fumes; the committee had done nothing in that matter. Mr. Beneké alluded to the difference between flame and reflection and considered it impossible that they should see certain things, but that gentleman did not give the results of any experiments to show that his contention was correct. The committee's experiments proved that what Mr. Beneké considered

to be impossible, was opposed to the actual facts, as demonstrated time after time. Flame had been seen repeatedly in, and passing through, explosive mixtures without ignition of the gas, although the heat was much more intense than that of a lighted match, and on more than one occasion, the gaseous mixture became ignited at the far end of the chamber, with an appreciable interval of time between the ignition of the explosive and of the gaseous mixture; in such cases the effects of the explosion was of exactly the same nature as it would have been if the gases had been ignited at the far end of the chamber with a lighted match.

Mr. A. C. Kayll said that Mr. Beneké in the previous discussion* had said that the ignition of the gaseous mixture was due to the detonator and not to the explosive; and that such ignitions would not have occurred if charges of 16 ounces and upwards had been used, as the gases of the heavier charges would have damped the flame produced by the detonator before they could reach and ignite the gaseous mixtures. He thought that view must be somewhat a matter of conjecture, and it certainly did not accord with the results obtained by the committee. Mr. Blackett agreed with the eighth recommendation of the committee as to miss-fires, but objected that it was dangerous to fire a second shot if employed in mines. If they got rid of the original charge by inserting a second charge in the hole, they were liable to a blown-out shot, because a double weight of explosives would be used to do the work, and Mr. Blackett thought that there was more danger. He thought that the danger was not so great as at first sight appeared, and certainly there was no extra risk of a blown-out shot, because if the original charge would act upon the coal and not blow out the stemming, double the quantity of explosive would the more readily so act. If the detonator was properly fixed and not disturbed by the action of stemming, miss-fires might occur from three reasons: (*a*) faulty explosive, the detonator being a good one; (*b*) a faulty detonator owing to the absence of fulminate, or the fulminate being inert the detonator was a dummy, the explosive in this case being good; and (*c*) the detonator wires being short-circuited or the flash not reaching the fulminate owing to faulty manufacture, the explosive in this case also being good. Supposing they got rid of those charges which had miss-fired by placing another charge in the same hole in front of the original one (instead of adopting the present system of making another hole). Taking them in rotation as above: (*a*) It would be seen by the disturbed state of the stemming that the detonator had fired. A fresh

* *Trans. Fed. Inst.*, vol. viii., page 234

charge would be placed in the same hole, but not of the same weight, as there would be less length of hole owing to the first charge being in its place. The firing of this second shot would most probably not detonate the first charge, as the explosive was faulty, and therefore the extra danger was almost *nil*. The hole, however, would be cleared of some if not all of the explosive, which would be scattered and rendered harmless. (*b*) The detonator being a dummy, the firing of the second charge might or might not detonate the first (if the explosive was a nitrate-of-ammonia compound it probably would not detonate it), but in this case also the weight of explosive put into the hole would be smaller than the original charge. (*c*) The second charge would detonate the first, owing to the detonator in that charge being a live one, but again the second charge would not be of the same weight as the first. The extra danger was certainly increased, owing to the double quantity of explosive, and some of the gases would have little or no mechanical work to perform. On the other hand, was not the danger greater under the system of making and charging a new hole, which might be at some distance from or near to the first hole? If at some distance from the first hole, the shock from the second shot might not detonate the first charge, and this charge in its entirety, with the live detonator affixed, might be buried in the fallen coal and be set off by a workman accidentally striking the detonator. Assuming that the second hole be made near the first, the shock of the second shot would most probably detonate the first charge, and there would then be two full charges doing the work originally intended for one. The coal being partly acted upon a moment of time before the detonation of the old charge, the heated gases resulting from this charge would escape through the fissures made by the new charge. If the explosive used was dynamite in any of its forms, he could not but think that it would be much safer to get rid of a shot which had miss-fired by means of a primary charge placed in the same hole in front of the original charge, than by adopting the method of making a new hole and running a risk of having a lump of dynamite buried in the coal or stone which might be filled into the tubs, passed over the screens into the waggon, and loaded into a ship. The risk of a blown-out shot was reduced to a minimum, if a sufficient holing were made and the quantity of explosive necessary for the work were used. It was improper workmanship and a desire for the impossible that gave rise to blown-out shots.

The PRESIDENT then read the following quotation from Mr. Kendall's paper on "Miss-fires":—

Two cartridges, without a cap or fuze, were put into the bottom of the hole. These were stemmed with a certain thickness of clayey stemming; another cartridge or half-cartridge with a cap in it, and fuze attached, was placed on the top of this stemming, and a farther lot of stemming, generally not more than an inch or two, was put over this last cartridge or half-cartridge. The primary stemming, that between the two lots of explosive, was tried of all thicknesses up to 14 inches, and in every case the whole of the dynamite in the hole was exploded, and the work intended to be done by it executed satisfactorily. In one experiment 5 inches of paper was put between the two lots of explosive and 2 inches of paper on the top of the last cartridge, no clay stemming whatever being used. The hole was a very strong one, in the middle of a narrow forehead, but the ground got by it was all that could have been expected if any amount or quality of stemming had been employed.

The lesson to be learned from these experiments is this: it is quite unnecessary to put more than 3 to 6 inches of stemming at the most into a hole, but if this were increased, say, to 8 inches in deep holes, so as to partly meet the prejudice of miners generally, yet even then in case of a miss-fire, all that has to be done is to put another cartridge, or part of one, on to the top of the stemming, and the first charge will be exploded in the manner described above. No unramming of a hole is necessary, and no pricker need be used, so that all the risks attending these two operations will be avoided.*

Mr. A. C. Kayll said that Mr. Kendall's remarks applied to nitro-glycerine compounds, such as gelatine-dynamite, blasting-gelatine, and gelignite; nitrate-of-ammonia explosives could not be dealt with in the same way, as the original charge would probably not be detonated unless the shock of the new charge communicated it to the live detonator in the original charge, which in its turn might act upon that charge.

Mr. Saville Shaw said that objection had been taken to the method of testing with leaden blocks. That method had been decided upon by the committee because it was most convenient and involved the least expenditure of time and money in procuring apparatus. And, after all, the conditions of firing an explosive were quite comparable with the conditions under which the explosive was fired in a mine. The method of testing with leaden blocks was to fire a small quantity of the explosive in a small hole. The explosive was surrounded with soft lead and tamped with sand, and the conditions were not altogether different from those prevailing in a mine, where they had the resisting coal or stone and the tamping. Of course, it only gave fairly comparative results with high explosives and strong detonation, and it was never intended that the results obtained with blasting-powder should be compared with those obtained from high explosives. He thought that too much stress had been placed upon this point, and that the method was a reliable one for comparing the detonating explosives. With reference to the observa-

* *Trans. Fed. Inst.*, vol. vii., page 608.

tion of flames from 10 to 62 feet in length passing through 10 per cent. coal-gas mixtures without ignition, some little explanation was necessary. The explosion of a gaseous mixture depended upon several factors. With regard to the temperature of detonation of the explosive, it seemed natural at first sight to suppose that if the explosive had a temperature of detonation higher than the temperature of ignition of the gaseous mixture, it ought in every case to fire it, but they knew that this was not so. There was no known explosive which had a temperature of detonation as low as the temperature of ignition of a mixture of pit-gas and air (which might be ignited by a temperature of about 670 degs. Cent.). All the high explosives had a temperature of detonation far above this, and yet it did not and should not follow, that they would ignite the mixture, because the length of time during which the hot products of combustion were in contact with the gaseous mixture must also be taken into consideration. Also as pointed out in the *Report*,* the experiments of the Prussian Fire-damp Commission showed that thin platinum wires melting at a temperature of 1,775 degs. Cent. could be melted in the midst of an explosive mixture of pit-gas and air, which had a temperature of ignition far below this, without causing its ignition, owing to the small volume of the heated body. The time during which the heated body was in contact with the explosive mixture had an important bearing; as also had the volume or bulk of the heated substance. If they took a white-hot body and plunged it suddenly into an explosive mixture, withdrawing it as suddenly, there would be no ignition, because the whole mass had not been raised to the temperature of ignition. In connexion with this, he might mention an experiment with gunpowder and gun-cotton frequently exhibited at lectures. The temperature of ignition of gunpowder was roughly 300 degs. Cent., the temperature of combustion of gun-cotton being 1,455 degs. Cent. One would naturally suppose that it would be utterly impossible to ignite gun-cotton in contact with gunpowder without firing it, yet it was possible to take tufts of gun-cotton, sprinkle them over with gunpowder, and after lighting the gun-cotton to find the grains of gunpowder lying unburnt. In that experiment, the time was too short for the high temperature produced by the gun-cotton to ignite the gunpowder. There were also mechanical causes of non-ignition. The ignited gases had so tremendous a velocity, that they did not allow time to fire the explosive mixture, even though the temperature of ignition of the gases was very much lower than the temperature of the hot gases which were passing through it. Therefore, they must

* Page 38.

consider not merely the temperature of detonation of the explosive as compared with the temperature of ignition of the gaseous mixture, but the velocity and also the volume of the heated gases which passed through the explosive mixture. A small quantity of an explosive need not necessarily explode the gaseous mixture, whereas a larger amount of the same explosive might do so.

Mr. W. C. Blackett said that to go fully into the question of stemming would involve a lengthy discussion, so he would therefore only answer one or two points. If there was so little importance to be attached to stemming, as some of the speakers implied, it seemed to him incomprehensible that the committee had used stemming at all, and a difference had been found by the committee between the use of stemming and no stemming. If it were proved that stemming was to some extent effective, it seemed to him to follow logically that the amount of stemming must have some importance. He was not prepared to say that this should follow a simple ratio, but it must have some effect. His own experiments were confirmed by those made a few years ago by Messrs. W. Foggin and M. Walton Brown, in which they used, unlike the present committee, seggar-borings which had a tendency to set, and they came to the conclusion that the length of stemming had a considerable effect on the safety of an explosive,* and he contended that if the most efficient material for stemming were used, it would have a decided effect on the safety of an explosive. Mr. Hedley said he (Mr. Blackett) used the term "wet clay," but the words he really used were those of the committee "damp puddled clay." He did not intend to state that explosives were not defectively mixed, but what he complained of was that the committee had come to the conclusion that the defects in explosives "appear to be due in some measure to defective admixture," but had produced no evidence whatever to show that this was so, and he considered that the committee should have recorded some facts proving their statement. As to plugged and unplugged detonators, he found on reference to the report of the French Commission, that—

> The principal difference between the unplugged and the plugged detonators is that, in the latter, the fulminate placed at the bottom of the cylinder is almost covered by a small metallic bonnet, with an orifice at the top, which exposes the fulminate and allows firing to be effected. Moreover, the thickness of the metal is greater, and the fulminate, being more compressed, has a greater density. †

* *Trans. Fed. Inst.*, vol. ii., page 489.

† *Report of French Commission.* Translation, page 41.

In other words, the copper tube with the fulminate of mercury was stemmed. A little copper ring was inserted, and allowed it to be exploded in a very favourable way. Not only were plugged detonators used in the experiments of the French Commission, but the resistance of the copper case was increased by wrapping with wire. He was pleased to hear Mr. Kayll's remarks upon the eighth recommendation, as they added much information to that contained in the *Report*.

The farther discussion was adjourned.

The meeting then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, FEBRUARY 9TH, 1895.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council of that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. ALEXANDER AGASSIZ, Mining Engineer, Museum of Comparative Zoology, Cambridge, Massachusetts, United States of America.

Mr. THOMAS BATES, Colliery Manager, The Grange, Prudhoe-upon-Tyne.

Mr. ROBERT GILMAN BROWN, Mining Engineer, P.O. Box 946, Butte, Montana, United States of America.

Mr. WILLIAM CLIFFORD, Mining Engineer, Pittsburgh, Pennsylvania, United States of America.

Mr. JOHN S. CRAWFORD, Consulting Engineer. Kingston, Sierra County, New Mexico, United States of America.

Mr. JOHN HENRY DARBY, Steel Manufacturer and Engineer, Pen-y-Garth, Brymbo, Denbighshire.

Mr. DAVID EVAN DAVIES, Colliery Manager, Cwmaman Colliery, Aberdare.

Mr. THOMAS INGLEBY DYSON, Metallurgist, Mount Morgan, Queensland.

Mr. EDWARD EDWARDS, Colliery Manager, Maindy Pit, Ocean Coal Company, Ton Pentre, South Wales.

Mr. G. GRAVES GIFFORD, Mining Engineer, Perth, Western Australia.

Mr. GEORGE ERNEST GREGSON, Land Agent, Land and Mine Surveyor, 11, Chapel Street, Preston.

Mr. JOSEPH HADFIELD, Colliery Manager, Hulton Collieries, Chequerbent, Bolton, Lancashire.

Mr. DAVID HANNAH, Mining Engineer, Brynderwen, Ferndale, South Wales.

Mr. C. D. SULLIVAN, Mining Engineer, Bonang, Delegate, New South Wales.

Mr. JESSE WALLWORK, Assistant Mining Engineer, Haydock Colliery, near St. Helens, Lancashire.

ASSOCIATE MEMBER—

Mr. GEORGE BENEKÉ, Managing Director of an Explosives Manufacturing Company, 70, Gracechurch Street, London, E.C.

ASSOCIATE—

Mr. JOHN RIVERS, Master Shifter, Front Street, Tudhoe Colliery, Co. Durham.

STUDENT—

Mr. HENRY SCOTT STRATTON, Mining Student, Cramlington Collieries, Northumberland.

DISCUSSION UPON PROF. STROUD'S PAPER ON "MAGNETIC DECLINATION AND ITS VARIATIONS"* AND MR. JAMES HENDERSON'S PAPER ON "MAGNETIC DECLINATION IN MINES."†

Mr. ARTHUR BEANLANDS (Durham) said that the miner's compass had been generally used as an instrument for underground surveying for very many years, and possessed considerable advantages for that purpose. It was not, however, an infallible instrument, particularly in mines where much iron was used; and it was not attended with that degree of precision which would be required in special surveys, such as the defining of boundaries, etc. In the case of surveys requiring special care he advocated the use of the theodolite, in conjunction with the transit-instrument, to connect the surface with the underground survey. After the main lines of the survey had been laid down with the theodolite in this manner, the miner's compass was very useful in filling in details. In cases where the shaft was either very narrow, or so tortuous that the transit-instrument could not be used, he had sometimes depended on the position of two shafts (if the shafts were at a considerable distance from each other). He endorsed the desirability of paying attention to the annual variation in the magnetic declination, as in the course of a few years the difference became somewhat considerable. As the miner's compass could not be read to less than one-quarter or one-eighth of a degree, the diurnal variation scarcely made any perceptible difference.

Mr. J. A. RAMSAY (Littletown) generally endorsed the remarks made by Mr. Beanlands. In underground-surveying, the first great object to be attained was accuracy of departure from the bottom of the pit, and this certainly demanded the most special care and manipulation of the instrument used. To make an accurate survey of underground workings such an instrument as the theodolite was absolutely necessary, but he questioned whether the degree of accuracy which the workings of an extensive colliery demanded could be obtained from a base-line, the length of which could not by any possible means exceed a very small

* *Trans. Fed. Inst.*, vol. vii., page 268. † *Ibid.*, vol. viii., page 273.

fraction more than the diameter of the pit shaft. On the surface of the ground the base-line might be prolonged to practically any distance. At the outset any inaccuracy in the collimation of the transit-instrument placed over the pit mouth would give erroneous points at the bottom, and again in placing the instrument at the bottom of the pit, if its axis was not fairly over the point registered in sighting down the pit, whatever the deviation might be here, on this short base-line, the inaccuracy would become larger and larger as the survey advanced. It must be admitted that on plain traversing work, and using the greatest care, the imperceptible differences in reading the verniers would amount to a few minutes even in a small survey, but in this case there is more chance of such small errors compensating each other than in sighting down the pit, and the building up or construction of a large plan on so short a base-line. In preference to using the transit-instrument for sighting down the pit and using a base-line of such limited length, he thought much better results would follow by making a careful traverse, and triangulating between two or more pits, and the more pits connected with the surface the better, because they best of all prove the accuracy or the contrary of any underground survey. In this case the base-line might be of very considerable length, and all that was required was that the centre of the shaft shall be carefully noted in the measurement from the starting point. On the centre of the second shaft being reached its centre would also be carefully noted, and, if possible, the survey continued in a circuit back to the starting point of the first line and the angle taken upon it to its end. On the completion of such a circuit, any error in the triangulation would show on the last reading of the verniers, or could be proved by summing up the whole of the interior angles.* The shafts being vertical, the centres at the tops will be over the centres at the bottoms of the shafts, and on completion of the plan plotted from such a survey as that named if the centres of the shafts as shown by it be placed on a plan of the surface drawn to the same scale, both being accurate they will coincide with each other ; and similarly equal care having been used the whole of the workings so surveyed will be shown in their true position in reference to the boundaries or any other objects on the surface of the ground. If it be not practicable to traverse the workings around the bottoms of the pits, the survey ought to be made back over from No. 2 pit to the starting point of the survey or of the first line measured.

* All the interior angles of an irregular polygon are equal to twice as many right-angles as the polygon has sides, less four right-angles, and any difference would be the amount of error.

By fixing permanently the points of such surveys, every line between any two points practically becomes a base-line for future use. He (Mr. Ramsay) further remarked that where it was possible to traverse a circuit round the bottoms of any number of pits it was desirable to do so, because the imperceptible errors arising in reading the vernier and the adjustment of even the best instruments might compensate each other, or at all events they would be minimised.

The PRESIDENT said that Mr. Henderson, in his paper, mentioned one or two points upon which Mr. Beanlands might say a few words. One of them was "in the now abandoned Crown portion of this mine, which extends for a long distance beneath the bed of the Atlantic Ocean, a great amount of local magnetic attraction prevails, rendering compass-bearings quite unreliable."* Then he went further in the same direction as Mr. Ramsay: "In a recent underground survey at Wheal Cock, the surveyor was obliged to seek for a true bearing at a distance of $\frac{1}{4}$ mile from the shaft, and using a draft-line at that place of only 16 feet in length as his base, he carried on the whole of his subsequent survey by means of an angular instrument of recent invention, without reference to any further needle-reading. The work involved no less than 363 draft measurements, and occupied seven days in its accomplishment."† The shaft might be of such a character that they could not look down it from the surface to the bottom, and what he was anxious to ascertain was what steps might fairly be taken by any one who had to bring into account the variation owing (it might be) to local circumstances, or the ordinary magnetic variation, to ensure correctness.

Mr. BEANLANDS said that he was not sure whether he understood the question aright. In cases where the shaft was not perpendicular, and they could not see from the top to the bottom, he knew of no better method than of either surveying to a second shaft, if there was one within a reasonable distance, or falling back upon the miner's compass. With regard to the width of the shaft, he had made the necessary connection in many shafts of different widths, but had rarely had occasion to make a survey where the shaft was not of sufficient width for the purpose. Several years ago a bearing was taken at Ryhope colliery in a shaft sunk to the depth of 1,524 feet. The process was repeated a year or two afterwards, the two results being nearly identical. If two independent plans had been made from the two bearings the difference would not have been perceptible at a distance of two miles from the shaft. He had had considerable experience in surveying from two

* *Trans. Fed. Inst.*, vol. viii., page 273. † *Ibid.*, page 274.

shafts. In one case the shaft was inconvenient for planting the transit-instrument, owing to the presence of timber of a character not suitable for mounting the instrument, and he adopted a base-line from two shafts. There is occasionally some difficulty and great extra labour involved in surveying from two shafts, and the results are rarely as accurate as those obtained from the transit-instrument.

Mr. J. A. Ramsay agreed that it was quite impossible to get a base-line by hanging strings down the pit. Certainly the proper method of surveying must be to get as nearly as possible point over point. In all surveying there were so-called imperceptible errors arising from the reading of the instruments, and in taking a transit-line down a shaft up to 14 feet in diameter, the base-line was too short. In making mining surveys the magnetic base-line of the miner's compass ought not to be used excepting only as a continuation of the minor workings from the lines and points established by the theodolite.

Prof. Stroud wrote that he thought the magnetic compass should continue to prove of important service in mine surveying. The periodic variations (viz., annual and diurnal) were too small to affect its ordinary use. The secular variation, although small, was cumulative, and should of course be taken into account. The irregular variations were known from the records taken at magnetic observatories, as wide areas were affected simultaneously. The local disturbances noted by Profs. Rücker and Thorpe were not serious in Northumberland and Durham. He might mention that the magnetic axis was not necessarily coincident with the line joining the ends of the needle, and perhaps some of the difficulties experienced in surveying might be due to this cause. In case the magnetic axis was not coincident with the line joining the ends of the needle, the magnetic meridian would not be exactly given by a single reading of the needle. The error, however, might be avoided by taking a second reading with the other face of the needle turned downwards, and the mean of the two readings would give the correct magnetic meridian. His (Prof. Stroud's) remarks on this head were rather to suggest that the magnetic meridian for very careful work could not necessarily be obtained with a single reading. In making an underground survey, no definite conclusion could be drawn as to the magnetic meridian unless the needle remained parallel to itself, as tested at several positions along a base-line. If the direction of the magnetic needle be indicated on the plan at the various positions of the survey, and it be found that the needle remained parallel to itself at several positions, as tested along a base-line, then it might be concluded that there was no

magnetic disturbing cause in the immediate neighbourhood. He (Prof. Stroud) considered that no conclusion could be drawn from the compass unless an undisturbed position could be found somewhere in the workings.

Mr. James Henderson (Truro) wrote that the remarks made during the discussion rendered it desirable that he should enlarge somewhat on his previous statements, with the object of rendering them of greater service to the mine surveyor. It was said that the compass although possessing "considerable advantages for underground surveying was not, however, an infallible instrument, particularly in mines where much iron was used," and that its use "was not attended with that degree of precision which would be required in special surveys such as the defining of boundaries, etc." The author differs widely from this expressed opinion: From his experience during many years of the use of the miner's dial or compass in Cornish metalliferous mines, where, except perhaps in the instance of the Crown shaft of the Botallack mine, no underground survey could be connected by means of a transit or theodolite with the surface as is the case in collieries, he firmly believed in the adaptability of the magnetic needle for the minutest survey, even where inches are of importance, as they would be in the boundary of a valuable mine, but then it must be used with care and circumspection throughout, and bearings only recorded where proof could be obtained of their correctness. Any traverse over rails or in the neighbourhood of local attraction must be made either by means of what is termed the rack in the miner's dial, with the needle thrown off, or by entering the bearing of the loose needle for every back and forward sight, and afterwards calculating the correct bearing of each line of the traverse. The adoption of this system he (Mr. Henderson) highly recommended, especially where the tripod-stands used are old and shaky and liable to the effects of torsion. Where the legs are firm and rigid any angular instrument of proper construction may be used where local attraction occurs, provided one or more drafts of the traverse be entered at their true magnetic bearing. He (Mr. Henderson) had found his "rapid traverser" well adapted for this purpose, the liability to error in reading and booking the angles or bearings of the traverse drafts being entirely avoided by its use.* It had been stated during the discussion that the miner's compass could not be read to less than one quarter or one eighth of a degree. He (Mr. Henderson) had always used in his miner's dial a needle mounted on a ruby, with a vernier attached to its north-seeking end reading to single minutes, and very precise bearings could in

* *Trans. Fed. Inst.*, vol. v., page 199.

consequence be taken by its means. It was highly important that both surface and underground surveys should be made with the same instrument if it be necessary to connect them. There was nothing gained by surveying at the surface with a costly transit or theodolite and attempting the underground work with a humbler instrument. On the contrary, in all probability their readings would differ considerably, and there would be a corresponding error in the resulting plan. Whereas, by working with the same instrument in both instances, even if the less showy one be used, the traverse would most likely be found to be correctly performed.

DISCUSSION ON MR. J. D. KENDALL'S PAPER ON "MISS-FIRES." *

Mr. J. D. Kendall wrote that the following Special Rule had been adopted in certain hematite mines under his charge :—

All holes fired in this mine must be charged in such a way that not more than 5 inches of stemming shall be used in holes 18 inches deep and under, and not more than 8 inches in a hole of greater depth than 18 inches. In case of a miss-fire, no attempt shall be made to remove the stemming, but another cartridge must be placed on the top of it and one or two inches of additional stemming. The latter cartridge must then be fired in the usual way. If the bottom cartridges should not be fired by this means, the hole must be left and information given at once to the manager or his deputy. Further, in case of a miss-fire, no one shall enter the working where such miss-fire has occurred before the lapse of twenty minutes.

DISCUSSION UPON MR. R. RUSSELL'S PAPER ON "THE EXTENSION OF THE WEST CUMBERLAND COAL-FIELD, ETC."†

Mr. J. D. Kendall (Whitehaven) wrote that he found that some of the details in Mr. Russell's paper could not receive general acceptance. Mr. Russell said that "the workings from the old shafts in the vicinity of Preston Hows were carried under the St. Bees Sandstone. From the Croft pit, the coal had been worked for some distance in the direction of Sandwith, and the base of the red rock proved by boring upward from the underground workings."‡ The red rock here referred to was clearly supposed to be St. Bees Sandstone. That view had also been held by the colliery officials and, in consequence, the 240 feet fault or dyke beyond which the red rock was proved had, since 1849, when the boring was made, been known as the St. Bees dyke. Although not material to the subject

* *Trans. Fed. Inst.*, vol. vii., page 605. † *Ibid.*, vol. viii., page 276. ‡ *Ibid.*, page 278.

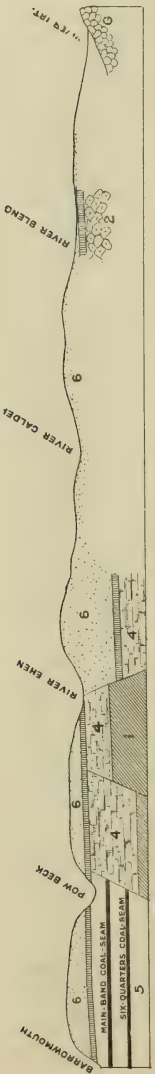


Fig. 4.

of Mr. Russell's paper, it might be stated, as a matter of fact, that the red rock in question was not St. Bees Sandstone but Whitehaven Sandstone, as would appear from a consideration of the evidence. The boring was put upward from the yard band drift, at a distance of about 660 feet from the fault and on the downcast side of it. The rocks passed through were the ordinary shales, sandstones, and coals of the Middle Coal-measures up to 173 feet in thickness. Red sandstone was then entered for 9 feet until the boring was stopped. Before the St. Bees Sandstone could have been reached the hole would have had to pass through about 167 feet more of Whitehaven Sandstone and then through a greater or less thickness of breccia, Magnesian Limestone, and red shales with gypsum, as there was no fault which could have thrown off these rocks. Mr. Russell further says that "the inclination of the coal-seams at Whitehaven is towards the west and south of west, and the direction of the dip of the limestone in the neighbourhood of Cleator and Egremont has a similar bearing." And further, "taking the south-westerly direction of the dip as continuous throughout this comparatively unknown district to the south of Egremont, . . . the strike of the measures would range somewhat in the direction of the thick broken line shown on the map and approximately parallel to the coast-line."* The sections shown by Figs. 2 and 3 (Plate XVII.), it will be seen on reference to Fig. 1 (Plate XVI.) are parallel to one another and to the strike of the known and supposed coal-fields. The coal-seams appearing in Figs. 2 and 3 should therefore have been level and not dipping northward as shown. The same remark applied to the Carboniferous Limestone. There was not sufficient data to enable anyone to make a section

Fig. 4.—Section from Barrowmouth to Muncaster Fell.

References.

1. Skiddaw slate.
2. Volcanic series of Borrowdale.
4. Carboniferous Limestone.
5. Coal-measures.
6. St. Bees Sandstone.
G. Granite.

* *Trans. Fed. Inst.*, vol. viii., page 279.

along the line of Fig. 3, but on the line of Fig. 2 there was a considerable amount of information, but this Mr. Russell appeared to have disregarded, or his section would have been similar to Fig. 4. Mr. Russell also stated that the probable depth of the Coal-measures would be from 1,300 to 1,400 feet.* There was not a scrap of evidence to support this statement, nor for other similar estimates of depth near Allonby and Carlisle; indeed, in the present state of knowledge such estimates were the merest guesses, and more information must be obtained before any reliable opinion can be expressed.

DISCUSSION ON MR. SIMON TATE'S PAPER ON THE "SAVING OF LIFE FROM AFTER-DAMP, SMOKE, OR FUMES IN MINES."†

Mr. Tate said that he had had an opportunity of testing his proposed system in a small district, which was shut off for twenty hours from the ventilation of the mine. After this interval, on the district being re-entered, they were able to visit the greater part of the district, and to reach the face of the workings. This test showed that his proposals were capable of being of practical use.

Mr. W. Ramsay (Tursdale) said that all mines were not so situated that the doors contemplated by Mr. Tate could be inserted. He also suggested that the doors might not always be in working order when an explosion took place, even if the men were properly instructed how to shut the doors. Men should be instructed to open the separation-doors so that the after-damp of an explosion could get away into the return-airways. If the mine was ventilated by a furnace or furnaces, and the fire was blown off the furnaces, the heat remaining in the shaft would maintain the ventilating-current. If the ventilation was produced by means of a fan, it would be necessary to run it as hard as possible, so as to get the after-damp out of the pit. If a fire was found on any of the roadways, the mode of procedure would depend on circumstances; if it was simply burning coal, he would think nothing of passing beyond it; but if it was inflammable material, every precaution should be used. He thought all officials, especially deputies and overmen, should carefully consider what should be done if an explosion should take place at the out-bye end of the mine.

* *Trans. Fed. Inst.*, vol. viii., page 280. † *Ibid.*, page 189.

Mr. J. A. Ramsay (Littletown) said that the essential thing to be done after an explosion was to get the ventilation restored. He suggested the use of duplicate separation-doors, which could be put into use should those ordinarily employed be destroyed. He thought it undesirable that there should be a long drift on the surface between the top of the upcast shaft and the fan. He considered that it was much safer to place the fan within a reasonable distance, say 8 or 10 feet, from the top of the upcast shaft. If an explosion occurred, and its effects reached to the surface, the force of the explosion would take a direct line upwards, leaving the fan undamaged. The drift connecting the fan with the top of the upcast shaft would be exposed to less risk of damage or destruction, and from its short length of 10 or 15 feet would be more speedily repaired than a longer length.

Mr. S. Tate said that some of the members suggested that it was only necessary to open a door here or to break a hole there, in order to remove the after-damp; but more than that was required in order to prevent the after-damp from passing into some of the districts which had not been affected by the explosion. In one case, the lives of 126 men were saved through a deputy placing them between two ventilating-doors. The deputy went in-bye and found the after-damp, a crossing having been blown out on the out-bye side. He took his men back to the ventilating-doors, and all of them were saved. Many men had been killed after an explosion, as they were not properly acquainted with the return-airways or did not know what to do.

The President said no doubt Mr. Tate had instructed the principal officials at the collieries under his charge, as to the course they should adopt on the occurrence of an explosion; and possibly when he had reduced his rules to writing, he might give the members the benefit of a knowledge of these rules. His paper was a very valuable one, and pointed to the desirability of increasing the knowledge of the officials in charge of collieries, so that they might use a large amount of intelligence in the event of any explosion taking place.

Mr. J. L. Hedley (H.M. Inspector of Mines) said he could not allow the opinion to pass unchallenged as to the proper position of a ventilating-fan. He did not know whether Mr. Ramsay was speaking from actual experience as to the results of an explosion or not, but it would be well if he (Mr. Hedley) were to quote an occasion where the fan was some distance from the upcast shaft; and owing to its being at such a distance it was found undamaged after an explosion, and was capable of use immediately afterwards. Speaking in a general way, he was of opinion

that the farther away the fan was placed from the top of the upcast shaft the less liable it was to injury.

Mr. J. A. Ramsay said that he believed the right course to adopt was to place the fan closely adjacent to the top of the upcast shaft, which should be covered by a light valve, so that the force of the blast of an explosion might not be diverted into the fan-drift and cause serious damage to the drift or to the fan.

Mr. J. L. Hedley said that at Abram colliery, in Lancashire, where 50 or 60 lives were lost by an explosion, the Guibal fan resumed work within a few minutes of the accident. The top of the upcast shaft and the top of the drift from the shaft to the fan were destroyed, but were temporarily replaced. If this fan had been placed within a few feet, instead of 120 feet, from the top of the upcast shaft, it would certainly have been destroyed. The Guibal fan, placed 150 feet from the upcast shaft at Pemberton colliery, near Wigan, was uninjured, and was not even stopped by the explosian.

Mr. T. Bell (H.M. Inspector of Mines) said that it was a fact well known to all practical mining engineers that, if the fan was placed within a few feet of the upcast shaft, it would certainly be damaged by the blast of an explosion. In addition, General Rule 3, of the Coal Mines Regulation Act of 1887, provided that a fan should be placed at a sufficient distance from the pit to prevent its being injured by an explosion.

Mr. T. W. Benson (Newcastle-upon-Tyne) said that he was glad to be fortified by the opinion of two of H.M. Inspectors of Mines, that he had not been wasting about 50 per cent. of the expense of a new fan by placing it at a distance of 60 feet from the top of the upcast shaft.

Mr. T. L. Elwen read the following paper on "The Effect of an Obstruction in the Airway of a Mine":—

THE EFFECT OF AN OBSTRUCTION IN THE AIR-WAY OF A MINE.

By T. L. ELWEN.

The subject-matter of this paper, based on a statement made by Mr. D. Murgue in his paper on "The Friction of, or Resistance to, Air-currents in Mines,"* ought more properly to have been brought forward in the discussion which followed. A protuberance of the roof is shown in Fig. 22, with reference to which Mr. Murgue states "If this protuberance were preceded and followed by a progressive curvature of the roof (as shown by the dotted line) corresponding to the depression of the seam, the amount of pressure absorbed in overcoming the obstacle would be restored after passing the obstacle, and there would be no loss. But the sudden widening beyond the protuberance causes a swirling and eddying, and a loss of pressure which is measured by the air-column due to the loss of velocity." However, in view of the importance of the point raised, further experiments seemed necessary, which are herewith recorded.

The position chosen for the experiments was a main intake haulage-road, of which Fig. 1 is a plan, and Fig. 2 a cross-section. The figures show the position of the obstruction and other bratticing erected for the purpose of the experiments.

The air-measurements were made by dividing the air-way by strings into squares, and the velocity was taken separately in each. These measurements were made at points at short distances out-bye and in-bye from the bratticing. Very little difference was noted between the two measurements, and the mean quantities are recorded in the tables.

Other necessary precautions and arrangements were observed to ensure accuracy. In each experiment, the velocity of the air-current was also observed at the water-gauge and end of pipe, as a correction in working out the differences of pressure (see Figs. 1 and 2).

The water-gauge F was screwed to a stand in the centre of the air-way, and near the commencement of the bratticing. Small iron pipes were attached to the water-gauge and were carried forward and terminated near the end of the bratticing G in the centre of the air-way. The end of the pipe was "padded." A range of hose-pipe was also connected with the

* *Trans. Fed. Inst.*, vol. vii., page 212, and Fig. 22, Plate VIII.

water-gauge with arrangements for making a connexion when necessary, and terminated in the centre of the open space at the obstruction *C*. Thus the water-gauge readings from the iron pipes represents the difference of pressure between the points *A B*, and is designated "pipe water-gauge." The second readings, designated "hose water-gauge," represents the difference of pressures existing between the point *A* and the obstruction *C*. The total length of air-way *A B*, covered by the experiments, is 84 feet, with an average sectional area of 34·375 square feet, perimeter of 23·5 feet, and total rubbing-surface of 1,974 square feet. At the obstruction, the sectional area is reduced from 30 square feet to 6·78 square feet.

Experiment No. 1.

The obstruction and the tail-brattice *D* and *E* at each end having been erected, the following observations were made:—Volume of air per minute, 25,545 cubic feet; velocity of air-current per minute at water-gauge, 990 feet; velocity of air-current per minute at pipe-end, 770 feet; pipe water-gauge, 0·465 inch; hose water-gauge, 1·000 inch.

Experiment No. 2.

In this experiment advantage was taken of adjoining ventilating-doors to divert part of the air-current. The object being to ascertain the effect of a reduction of volume under conditions similar to those of experiment No. 1:—Volume of air per minute, 15,444 cubic feet; velocity of air-current per minute at water-gauge, 600 feet; velocity of

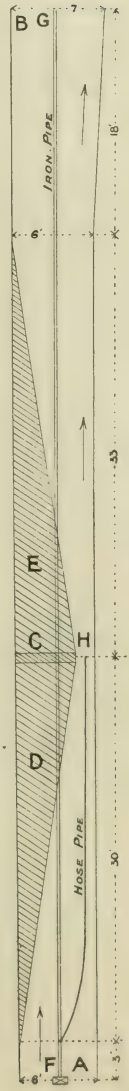


Fig. 1.

Fig 1.—Plan.
Scale, 12 feet to 1 inch.

References.

—> Direction of air-current.
C.—Obstruction.
D.—Outbye brattice.
E.—Inbye brattice.
F.—Water-gauge.
F G.—Iron pipe.
F H.—Hose pipe.

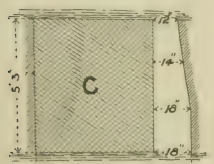


Fig. 2.—Section at Obstruction *C*.
Scale, 6 feet to 1 inch.

air-current per minute at pipe-end, 470 feet; pipe water-gauge, 0·175 inch; hose water-gauge, 0·375 inch. With similar ventilating arrangements and with the whole of the brattice and obstruction removed, the quantity of air per minute was 17,429 cubic feet.

Experiment No. 3.

The ventilation in this case was on its normal course, or under conditions similar to those prevailing in experiment No. 1. The out-bye end of the brattice *D* was taken down, the obstruction *C* and brattice *E* remaining in position:—Quantity of air per minute, 24,570 cubic feet; velocity of air-current per minute at water-gauge, 990 feet; velocity of air-current per minute at pipe-end, 820 feet; pipe water-gauge, 0·500 inch; hose water-gauge, 0·900 inch.

Experiment No. 4.

The in-bye end of the brattice *E* was taken down, leaving the obstruction *C* only in position:—Volume of air per minute, 22,308 cubic feet; velocity of air-current per minute at water-gauge, 920 feet; velocity of air-current per minute at pipe-end, 710 feet; pipe water-gauge, 0·700 inch; hose water-gauge, 0·725 inch.

Experiment No. 5.

To ascertain what differences, if any, existed in having the velocity of the air-current gradually brought up to, and the swirling and eddying as it leaves the obstruction, the out-bye end of the brattice *D* was re-erected, and the obstruction *C* left in position:—Volume of air per minute, 23,049 cubic feet; velocity of air-current per minute at water-gauge, 990 feet; velocity of air-current per minute at pipe-end, 740 feet; pipe water-gauge, 0·600 inch; hose water-gauge, 0·975 inch.

Experiment No. 6.

As a correction in working out the pressures, it was necessary to ascertain the amount of pressure lost on the rubbing-surface. For this purpose the whole of the obstruction *C* and brattices *D* and *E* were removed; the length of the air-way was extended to 205 feet, and it had a rubbing-surface of 4,817 square feet:—Volume of air per minute, 27,495 cubic feet; velocity of air-current per minute at water-gauge, 1,210 feet; velocity of air-current per minute at pipe-end, 1,030 feet; pipe water-gauge, 0·0468 inch.

From the data of No. 6 experiment, one can ascertain the loss of pressure and the co-efficient of friction for the rubbing-surface of the air-way. Thus the average velocity $= \frac{27{,}495}{34{\cdot}375} = 800$ feet per minute.

The difference of pressure $= 0{\cdot}0468 \times 5{\cdot}2 = 0{\cdot}243$ pound per square foot. The correction for difference of velocity

$$0{\cdot}243 + \left[\left(\frac{20{\cdot}17^2}{64{\cdot}4 \times 13}\right) - \left(\frac{17{\cdot}17^2}{64{\cdot}4 \times 13}\right)\right] = 0{\cdot}377 \text{ pound per square foot.}$$

The correction for the standard velocity of 1,000 feet per minute $\frac{0{\cdot}377}{0{\cdot}8^2} = 0{\cdot}589$ pound per square foot.

The co-efficient of friction $\left(= \frac{0{\cdot}589 \times 34{\cdot}375}{4{,}817} = \right) 0{\cdot}0042$ pound per square foot, practically corresponds with the value obtained by the writer in previous experiments on the same kind of air-way.*

The loss of pressure, as ascertained by the above calculation, due to the rubbing-surface in each experiment, was deduced from the area, velocity, etc., for each length of 10 feet from *A* to *B* when all the brattice or part, and when the obstruction only was in position. The value of the co-efficient of friction was used throughout, although the sides of the brattice as a plain rubbing-surface would offer rather less resistance.

TABLE I.—SUMMARY OF RESULTS OF EXPERIMENTS.

No. of Experiment.	Conditions of Experiment.	Volume of Air per Minute.	Pipe Water-gauge per Square Foot.	Velocity of Air-current as Water-gauge per Minute.	Velocity of Air-current as Pipe, round per Minute.	Corrected Water-gauge for Difference of Velocity per Square Foot.	Current Resistance per Square Foot.	Corrected Water-gauge, the Current Resistance being Deducted, per Square Foot.	Proportion of Current Resistance to Total Resistance.
		Cubic Ft.	Lbs.	Feet.	Feet.	Lbs.	Lbs.	Lbs.	
1	Obstruction C and brattice D and E	25,545	2·420	990	770	2·550	0·970	1·580	0·38
2	Do. do.	*15,444	0·910	600	470	0·950	0·350	0·600	0·37
3	Obstruction C and brattice E ...	24,570	2·600	990	820	2·700	0·670	2·030	0·25
4	Obstruction C ...	22,308	3·640	920	710	3·750	0·380	3·370	0·10
5	Obstruction C and brattice D ...	23,049	3·120	990	740	3·260	0·670	2·590	0·20
6	No obstructions ...	27,495	0·243	1,210	1,030	0·377	0·004	0·373	—
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

* With all obstructions removed the volume was 17,429 cubic feet per minute.

Taking the conditions prevailing in experiment No. 1 as a basis, the following results may be noted:—

* *Trans. N. E. Inst.*, vol. xxxviii., page 215.

TABLE II.

No. of Experiment.	Conditions of Experiment.	Decrease of Air.	Increase of Pressure.	Reduction of Volume of Air, the open Air-way being taken as a Basis.
		Per Cent.	Per Cent.	Per Cent.
1	Obstruction C and brattice D & E	Ba	sis.	7
2	Do. do.	—	—	11
3	Obstruction C and brattice E ...	4	28	11
4	Obstruction C	13	113	19
5	Obstruction C and brattice D ...	10	64	16

Other results are recorded in Table III.:—

TABLE III.

No. of Experiment.	Quantity of Air per Minute.	Average Velocity per Minute at Obstruction.	Highest Velocity per Minute at Obstruction.	Co-efficient of *Vena Contracta.*
	Cubic Feet.	Feet.	Feet.	
1	25,545	3,768	4,936	0·76
2	15,444	2,278	3,014	0·75
3	24,570	3,624	4,734	0·77
4	22,308	3,290	4,280	0·77
5	23,049	3,400	4,884	0·69
(1)	(2)	(3)	(4)	(5)

The velocity stated in column 4 of Table III. is found by adding together the velocity of air-current at the water-gauge and the velocity due to the head or equal hose water-gauge. It will be observed that the co-efficient of the *vena contracta* is nearly constant in all the experiments, except the last, in which case the brattice *D* was taken down, and, as might be expected, the co-efficient is smaller.

Conclusions.—So far, then, as the full brattice and obstruction is concerned, instead of "the loss of pressure being again restored" there is a definite reduction of pressure. This is further proved by the reduction of the quantity of air in two experiments, equal to 7 and 11 per cent. respectively. After deducting the loss of pressure due to the current-resistance calculated by using the co-efficient of friction, as previously shown, there still remains a further loss of pressure to be accounted for. (See experiment No. 1, Table I., columns 7 and 8.) So far as the writer can see, this can only be accounted for by the fact of the air-current, tending to move in a straight line, being constantly deflected from a straight course at the brattice-sides from the point *A* to the obstruction *C*, and producing an additional resistance to the air-current.

It is evident that there is less resistance produced by increasing the speed of the air-current gradually up to the obstruction, than by gradually reducing the velocity after it leaves the obstruction. With the obstruction only, the loss of pressure is practically equal to the head required to produce the velocity at that point, a fact which confirms the accepted theory.

The PRESIDENT moved that a vote of thanks be accorded to Mr. Elwen for his paper, and the discussion was adjourned.

Mr. W. O. WOOD read the following paper on "The Murton Coal-washer":—

THE MURTON COAL-WASHER.

By W. O. WOOD.

It is generally admitted that the trough-washer is the simplest and the most efficient method of washing coal, so far as the purity of the products is concerned. But unfortunately it is expensive, in consequence of the excessive labour required, and wasteful, in consequence of the large amount of fine coal which is unavoidably carried away amongst the washed-out dirt. It has been generally discarded in favour of mechanical systems, which, perhaps, may not be so efficient, but are less wasteful and less expensive to work.

It is clear that if a machine could be contrived in which all the merits of the trough-system could be retained, and its defects remedied, a perfect washer would be secured. This has been attempted by the inventors of various machines, but with only partial success.

The Murton coal-washer is a trough or stream-washer, which perfectly fulfils these conditions. It combines the simplicity and efficiency of the trough-system with perfect washing, absence of waste, and economy of labour. It has now been in successful operation for upwards of one and a half years, and 400 tons of very fine duff-coal are treated per day of ten hours, with most satisfactory results.

The apparatus, which has been named the Murton coal-washer, consists of an endless articulated steel trough-belt, which is watertight. This trough revolves slowly round suitable drums at each end, to which motion is imparted by a simple arrangement.

The washer is continuous and automatic in its action, the clean washed coal falling into the washed coal-hopper at the lower end, and the refuse or dirt being delivered into a dirt-hopper at the upper end. The coal is washed perfectly clean and free from impurity, while the dirt is delivered practically free from coal. The cost of labour is reduced to a minimum, the same number of workpeople being required, as in all other systems of mechanical coal-washing.

The washer is equally available for all grades of coal, and is efficient for the finest and smallest as well as for the larger sizes. It will also wash mixed coals when required. For treating very small and fine coal it is, in the experience of the writer, the best system now in use.

The accompanying plans show the details of the arrangement. Fig. 1 is a general view of the plant; Figs. 2, 3, and 4 show the details of the trough-belt; and Fig. 5 shows the arrangement for securing a watertight joint (Plate II.).

Description of the Washer.

The steel trough is 60 feet long, 3 feet wide, and 8 inches deep, and it is fixed at an inclination of about 1 in 18. The supporting drums and rollers are mounted on a suitable frame. Dams or stops about 2 inches high are placed at intervals of 3 feet inside the trough. The joints are so constructed as to be perfectly watertight without the use of packing, and the dams form half of the joint of each 3 feet tray.

The method of feeding the coal into the trough is most effective in the prompt separation of the denser impurities from the coal. A short inclined plate (designated the "feeding-plate") is arranged immediately below the water-nozzle, above which is the coal-supply spout. The water in flowing down the feeding-plate floats and carries the dry coal, and delivers it with considerable force into the trough. The greater portion of the dirt is immediately precipitated and carried by the moving trough to the dirt-hopper, the coal flowing down the trough with the water. By this arrangement only 12 feet length of trough is required for washing away the dirt, thus allowing a length of 48 feet to be used for coal-washing.

The water is supplied by arrangements of the usual character, and the same water is used over and over again. About 450 gallons of water per minute are circulated when washing 400 tons of coal per day.

Method of Working.

The trough is set in motion and travels up the incline, towards the coal and water-supply, at a speed of from 8 to 10 feet per minute. The coal from the hopper *H* and the water through the nozzle *E* are turned on in suitable proportions, and the water, carrying with it the coal, flows downwards in a direction contrary to the travel of the trough, to the coal delivery end *D*, where the coal is delivered free from impurities.

The dirt, falling to the bottom of the trough, is arrested by the dams or stops *C C*, and is carried forward by the motion of the trough-belt beyond *E*, the point of supply. As soon as it passes this point it is agitated, so that any coal that is mixed with it is liberated and carried by the strong current of water supplied by the nozzle *J* downwards to *E*, where it joins the regular coal-feed, and is carried downwards with the other clean coal to *D*.

The refuse continues to be carried upwards to the end of the trough *M*, and as the belt turns round the drum *A*, it falls off into the hopper. The trough is washed clean by the water-spray *S*, and passes to the drum *B* at the lower end *D*.

The coal when delivered at the lower end *D* falls into a spout lined with a draining-plate (with 125 perforations of $\frac{1}{16}$ inch diameter per square inch), and the water is quickly drained away. The coal slides down the spout into the elevator-boot, whence it is raised and delivered into a large hopper, from which it is run into the coke-oven tubs as required.

In consequence of the very fine character of the coal, the drainage-water is heavily charged with it, and it has been found advisable to run the drainage-water through a series of settling-tanks, where part of the fine coal is deposited. After passing through these tanks the water returns to the pumps, and is used over again.

When the settling-tanks are filled (they are four in number and two are used alternately) the fine-coal or sludge is run out through the slides at the bottom on to a creeper-belt which conveys it to the boot of the elevator, where it is mixed with the other coal. The recovery of the sludge is perfect and inexpensive, there is no waste of water, and no fouling of the neighbouring streams.

All the washed coal is made into coke.

Cost of Washing.

The washery is worked as a separate establishment, and the coal is conveyed to it from the various pits in waggons. One workman is employed to tip the waggons, and another to attend to the engine and boilers; these workmen would not have been required if the washer had been attached to the pit-heap, the coal delivered or elevated direct from the small-coal apparatus, and power available from the other plant.

The cost of washing 400 tons per day, including all charges, is 0·76d. per ton. If the plant had been attached to the pit-heap the cost would have been 0·48d. per ton on the coal washed.

The washed coal contains 3·71 per cent. of ash, and the coke made from it contains 5·39 per cent. of ash. The coke made from unwashed coal contains 13·28 per cent. of ash.

It will be observed that this coal-washer is of an exceedingly simple and inexpensive construction, and the results, particularly in treating fine coal, are equal in every respect to what is obtained from much more expensive and elaborate plant.

In consequence of the slow speed of the machine, the cost of maintenance is small. The machines, at Murton, have not required repair since they started one and a half years ago, and they do not appear likely to require any repairs for some time to come. The power required to drive the trough-belt, apart from that used in pumping the water, which may be taken to be the same in every system, is very small, say, for two machines, about 1½ horse-power.

Mr. T. E. Forster (Newcastle-upon-Tyne) enquired as to the nature and percentage of the dirt washed out of the coal?

Mr. W. Cochrane (Newcastle-upon-Tyne) said that he had seen the coal-washer in operation, and he considered that Mr. Wood had not overstated the delivery of coal or the dirt washed out. Perhaps Mr. Wood would give the actual cost of the Murton coal-washing plant for an output, say, of 400 tons per day, without any extraordinary arrangements for handling the coals.

Mr. W. C. Blackett asked what was the size of the mesh over which the "fine duff coal" was passed? As to the comparison with more elaborate plants, such as the Lührig washer, there was a good deal of misapprehension, and if the Lührig were examined in comparison with other coal-washers he thought that they would not be found to be so much more expensive. The large sums so frequently referred to were paid for complete erections, including screening-belts, screens, settling-tanks, pumps, elevators, etc., in fact, the entire plant placed and used at the pit's mouth till the washed coal was delivered. If the Robinson, the Murton, and other coal-washers were attached to complete surface-plants, he thought that they would bear a similarly high cost.

Mr. F. Berkley asked what percentage of coal was contained in the refuse?

Mr. R. Thompson asked whether the sludge found in the settling-tanks had been analysed?

Mr. W. Ramsay asked what percentage of sulphur was contained in the coke?

Mr. W. O. Wood said that, at Murton colliery, the coals from three seams were washed and, as might be expected, the refuse was of a mingled character. One coal-seam contained much fine dirt, iron-pyrites, and shales; and another contained a friable band, but no difficulty was found in separating the refuse. There was the ordinary difference between the specific gravity of the coal and the refuse. The quantity of dirt washed

out was about 16 or 17 per cent. of the coal washed. If the washer were simply adapted to a pit-heap, as most washers were, the cost would be very little; but owing to the geographical position at Murton, the coals required to be elevated to the washer and from the delivery-spout of the washer to the coal-hopper supplying the coke-ovens. The cost of the whole plant, including the settling-tanks, which were of an inexpensive character, was about £2,000. The settling-tanks were not absolutely necessary, but they were used at Murton as a matter of convenience, so as to avoid any risk of the pipes or of the pump being choked. The gauze through which the duff coal passed (it was no guide or indication of the size of the coal going through, as the coal was of a very dusty character) was of $\frac{3}{8}$ inch mesh. The percentage of coal in the dirt did not appear to exceed 1 per cent. of the quantity of dirt. The sludge had not been analysed. The percentage of sulphur in the coke had been decreased, but it was one of those things that could not be washed out of the coal.

The PRESIDENT moved that a vote of thanks be accorded to Mr. Wood for his paper, and the discussion was adjourned.

The following paper by Dr. R. Brunck on "The Brunck Coke-oven and System for the Recovery of Bye-products" was taken as read :—

THE BRUNCK COKE-OVEN AND SYSTEM FOR THE RECOVERY OF BYE-PRODUCTS.

By R. BRUNCK, Ph.D.

The plant for coking with recovery of bye-products described in this paper has been erected and has been worked on an experimental scale at the Kaiserstuhl colliery, near Dortmund, and is the invention of Mr. F. Brunck.

A trial-battery of six ovens has been working since September, 1893, and is provided with a separate condensing-plant for the recovery of the bye-products—tar, sulphate of ammonia, and benzol.

The main features in the construction of the ovens (Figs. 1, 2, 3, 4, and 5) are :—

(1) The oven-chambers are 32·8 feet (10 metres) long, 6·56 feet (2 metres) high, and from 15 to 21½ inches (38 to 55 centimetres) wide in the middle (according to the quality of coal), and have vertical wall-flues like the Coppée-Otto ovens.

(2) In each wall, between two ovens, there are two series of heating-flues, separated by a solid wall carrying the entire weight of the vault. The heating-walls, having no weight to support, can consequently be constructed as thin as possible, so as to obtain the highest degree of heating effect.

(3) This method of separation provides each oven with an independent heating system, and thus prevents the heat from being wasted by the neighbouring ovens.

(4) By this mode of construction the walls separating the ovens are necessarily massive, and form an efficient magazine for the retention of heat and the maintenance of the high temperature in the heating-channels when the neighbouring ovens are being emptied. The strength of these walls is such that the ovens can be constructed of a greater height, and consequently for the same capacity, narrower than is possible in any other existing system of coke-ovens.

(5) The heating-gas for each oven enters by three pipes, one into each side, one into the bottom-flue, and two into the upper horizontal flues, thus securing an advantageous distribution of the heat, and at the same time excluding the possibility of overheating of the walls.

(6) The air used for combustion is heated in flues and channels, situated below the ovens, before it is brought into contact with the gases. The gases, after having heated the ovens, can also be utilized to heat boilers, etc.

The method of heating the ovens may be described as follows:—

The bottom-flue is divided into three parts by cross-walls. The heated air for combustion (the temperature of the air at Kaiserstuhl was 420 degs. Cent.) enters the bottom-flue at each side of the oven. The gases from

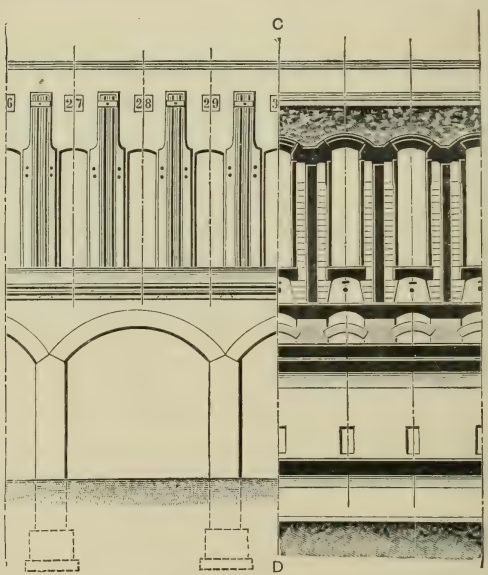


Fig. 1.—Front Elevation. Fig. 2.—Cross Section A B.

both sides are conducted through the middle series of flues downwards into the main flue below the ovens, along which they pass to the boilers.

The path traversed by the combustion-gases is a short one, and the gas used for heating is mixed with the air in the flues so intimately that the waste gases contain only $\frac{1}{2}$ per cent. of free oxygen.

The yield of bye-products obtained by this system of coke-oven is greater than with the Coppée-Otto ovens, which up to the present time,

have given better results than all other systems. This improvement may in part be attributed to the altered conditions of distillation in the oven,

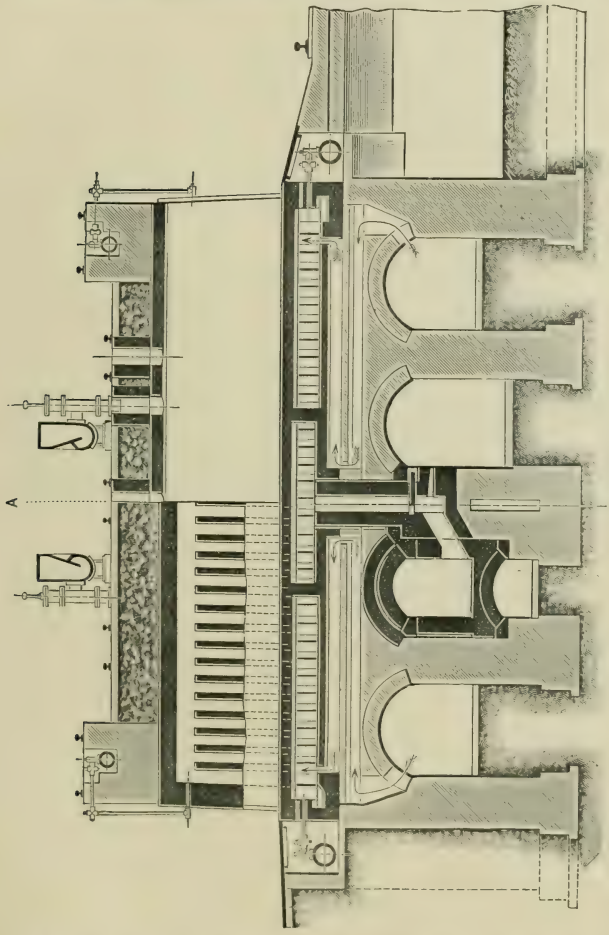


Fig. 3.—Cross Section C D.

but in the opinion of the inventor it is chiefly due to the fact that the obstacles to the flow of the gases in the flues are reduced to a minimum.

Consequently, there is little difference between the pressure of the gases in the flues and those in the oven; thus, equilibrium of pressure can be easily preserved, which almost entirely prevents the air used for combustion from entering the oven, and prevents at the same time the gas from escaping into the flues, although the joints in the several chambers cannot be kept perfectly tight. By this method of heating, no loss of bye-products can possibly occur, neither by the air used for combustion being forced into the ovens nor by gases escaping from them into the flues, without having previously passed through the condensing-plant.

The existence of obstacles in the flues interferes with the maintenance of this state of equilibrium of pressure, because they produce a difference of pressure between the gases entering and leaving the flues, whilst the pressure in the interior of the oven is practically the same throughout. These gaseous interchanges between oven and flues, and consequent loss of gases and bye-products will be the more considerable the greater the hindrance to the steady flow of gases along the flues.

Such conditions obtain in a marked degree in ovens with horizontal side-flues, as the heating gases must travel a considerable distance along narrow flues, the direction of which is repeatedly changed. In the opinion of the inventor this is the chief cause of the small proportion of bye-products yielded by ovens so constructed, as compared with the results obtained in the Coppée-Otto ovens. But even in this latter system the hindrances to the flow of the gases are greater than in the system described in this paper, because the whole volume of the heating gases is conducted into the flues from one side of the oven and has to be forced through one upper flue to the other side, whilst in the Brunck oven the gases are equally distributed in the two upper flues from each side, that is into four ways instead of one, and therefore the resistance to the flow of the gases is greatly reduced.

Favourable results have been attained as to quality and quantity of coke produced by the Brunck ovens. These advantages are to be attributed to the intensity of the heating process. The massive wall between two ovens retains a large amount of heat during each coking period, which is of service in the beginning of the next coking period when the flues are cooled by the introduction of a new charge of coal.

The independence of each oven is attained by the double series of side-flues, instead of one as in the Coppée-Otto and Simon-Carvès ovens. Thus, considering the process of heating of two neighbouring ovens in these systems, it will be noted that the temperature in the side-flue is lowest immediately after one of the ovens has been charged. It increases

gradually as the coking process proceeds, until the second oven is charged again. Now, the greater amount of heat is transmitted to the second charge at the cost of the first, which is stored up during the following coking period. When this first oven is again charged, it will do the same to the other one, taking away the greatest part of the heat for its own consumption. Consequently, in regular working, the temperature of the side-flues can never become higher than that attained in the middle of the coking period.

In ovens with a double series of side-flues the temperature rises continually up to the end of the coking period, without any reduction being produced by the loading of the neighbouring oven; the process is consequently accelerated, and a better quality and greater output of coke obtained. Owing to the equal distribution of the heat, the overheating of single parts is prevented, and the upper parts of the walls are heated

Fig. 4.—Plan of Bottom-flues.

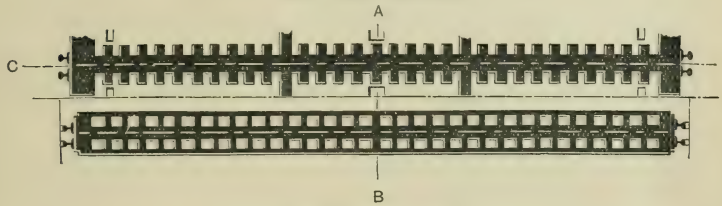


Fig. 5.—Plan of Side-flues.

intensely. This circumstance is of great importance, as the middle and upper part of the charge of coal is heated only from the two sides, whilst the lower part of the charge receives heat both from the walls and from the bottom of the oven. In the middle part of the vertical side-flues, the heating is generally imperfect, because the gases (partly used already) pass too rapidly through this portion of the flues. In the Brunck ovens this disadvantage is easily remedied. There being no great heating to fear, the thickness of the walls of an oven can be reduced as far as the quality of the fire-bricks used in construction will allow. The consequence is that the heat is transmitted more quickly to the charge of coal, and the temperature of the gases leaving the oven is lower. This temperature has been found at the Kaiserstuhl colliery to be 1,050 degs. Cent. in Brunck ovens, and with Coppée-Otto ovens working the same coal, 1,190 degs. Cent. Therefore the utilization of the heating gases in the Brunck ovens is the most perfect. Moreover, the massive and strong side-walls allow the ovens to be built higher, and in consequence,

for the same capacity, narrower than in any other system. And since the time required for coking increases with the width of the oven, which is greatly reduced in the Brunck oven, the time required for coking is as short as possible.

These points—equal distribution of the heat, favourable cross-section of the oven-chamber, and minimum thickness of the wall of the oven, combined with the independence of each oven, account for the better quality and greater output of coke.

Considering the fact that special arrangements for heating the air used for combustion are not required, and that by the central position of the main flue conducting the gases to the boilers the loss of heat must be greatly reduced, it is easily seen that in the Brunck oven the conditions for steam-production by the waste gases are exceedingly favourable.

The cost of erection and the working expenses are lower than is the case with other systems, owing to the ovens giving a better yield, and consequently the same weight of coke can be obtained from a smaller number of ovens.

The expenses for maintenance compare favourably with other ovens, because a partial destruction by overheating cannot occur, and the walls, owing to the lower temperature attained, seldom need repairs. Even when repairs are requisite, they can be performed without touching the massive middle walls and the vaulted roof, and without stopping any considerable number of ovens.

The practical results obtained at Kaiserstuhl colliery with the trial battery of six Brunck ovens are as follows :—The ovens are charged with 7·2 tons (7,200 kilogrammes) of coal, containing 14 per cent. of water, burning, on the average, for 34½ hours, the time for loading and discharging included ; whilst in two large batteries of Coppée-Otto ovens, worked with the same charge of the same coal, the ovens must burn for 44½ hours. This rapid burning of the Brunck ovens is obtained, notwithstanding the small number of ovens, which renders it extremely difficult to maintain an equal heating and production of gases, as every interruption of each oven affects one-sixth of the whole production. Another disadvantageous circumstance is that due to the stoppage of all work at the ovens on Sundays from 6 a.m. to 6 p.m.

The total output of coke produced from the Kaiserstuhl colliery coal, containing 20·5 per cent. of volatile matter, is 1,250 tons per oven per year, whilst the Coppée-Otto ovens worked under similar conditions produce only 925 tons.

The yield of tar produced by the Brunck ovens is 13·4 per cent. greater, and of sulphate of ammonia, 9·5 per cent. greater than that of the Coppée-Otto ovens. These figures are obtained by comparing the best period of the sixty-two Otto ovens with the average yield of the Brunck ovens.

The steam-production by the waste gases, freed of benzol, and containing only $\frac{1}{2}$ per cent. of oxygen and no carbonic oxide, reaches 820 gallons (3,650 kilogrammes) per oven per day; although the coals contain 14 per cent. of water.

The loss of heat in the small trial-battery is relatively much higher than would be the case in a larger one. Under normal circumstances the evaporation, by working the same wet coals, may be calculated at 990 gallons (4,500 kilogrammes) per oven per day. Deducting the amount of steam necessary for driving the plant for the recovery of tar and sulphate of ammonia, a surplus evaporation of 784 gallons (3,500 kilogrammes) per oven per day may be expected when coking wet coals of similar quality. When the coal contains a larger percentage of volatile matter, it has been proved by recent experiments that a constant amount of gaseous fuel, besides the waste gases, is available for heating boilers, etc. In this coking trial, with 300 tons of coal, containing 23·3 per cent. of volatile matter, 7·175 tons (7,175 kilogrammes) of coal containing 13 per cent. of water were coked in 30$\frac{1}{2}$ hours, representing an annual output of 1,375 tons of coke per oven.

The yield of bye-products has been so satisfactory that the inventor is able to guarantee for this description of coal a yield 15 per cent. higher than an estimate, based upon the results obtained by the Coppée-Otto ovens.

Mr. JOHN H. DARBY read the following paper on "The Semet-Solvay Coke-oven":—

THE SEMET-SOLVAY COKE-OVEN.

By JOHN H. DARBY.

In Northumberland and Durham, where large interests are connected with coal and coal-mining, and where naturally more care and attention has been paid to the development of these interests, it is strange that the question of better arrangements for the coking of coal should not have attracted more consideration.

With one or two exceptions, all the coke made in this district is carbonized in beehive coke-ovens. This statement applies almost equally to the whole of the United Kingdom. In South Wales alone has any extended attempt been made to coke coal in a retort-oven, and there no recovery of bye-products has been undertaken.

The reason for this state of affairs is possibly to be found in the fact that Durham possesses the most celebrated coking coal in the known world. This coal will coke, and coke well, in spite of the unfavourable conditions to which it is exposed in the beehive coke-oven. Then again the coal is cheaply raised, and the burning away of 10 to 20 per cent. of coal is not very noticeable. The beehive coke-oven is inexpensive to erect and maintain, and no great skill is required in conducting the coking operation. These reasons are borne out by the fact that in districts where the coals coke with difficulty great developments have taken place in retort-ovens, and such developments appear reasonable. For instance, in Belgium, the writer believes that no beehive coke-ovens are working at the present time, the whole of the coke used by the iron and steel-producing works in that country being made in retort-ovens. The large and well-appointed establishments of Messrs. John Cockerill & Co., Seraing, the Marcinelle & Couillet Co., Couillet, and the Phœnix Steel Co., Ruhrort, exclusively use Semet-Solvay coke in their high blast-furnaces, and recover the bye-products of the coking process.

It is not a fact that retort-ovens are only adapted for dry coals ; it is possible to coke dry coals in retort-ovens, and make good metallurgical coke, while the same coal treated in a beehive coke-oven would either not coke at all or make very inferior coke.

Coals containing from 14 to 15 per cent. of volatile matter up to rich coals with 35 per cent. of volatile matter are coked with ease in the

Semet-Solvay oven, and the best possible coke from any class of coal under treatment can be obtained, while a net yield in residuals, at present prices, of 5s. per ton of coke made, after paying royalty, is obtained with fairly rich coal.

There are alterations to be made in the plant varying with the coal to be treated: as a general rule the Semet-Solvay oven should be narrow for lean coal so as to coke very rapidly, and wider as the coal is more highly charged with volatile matter. Consequently per ton coked, the cooling, exhausting, and washing-apparatus for the gas must be larger for rich coals giving large quantities of gas than for lean coals with a much smaller amount.

The following table shows results obtained from some coals used in Semet-Solvay ovens :—

Oven used.	District from which the Fuel was obtained.	Class of Fuel.	Volatile Matter, not including Water.	Yield of Dry Coke.	Percentage of Ash in Coke.
Semet-Solvay	Durham	Slack...	23·32	80·50	7·50
,,	South Yorkshire ...	,, ...	31·93	71·10	10·80
,,	South Wales ...	,, ...	17·20	81·82	7·10
,,	North Wales ...	,, ...	32·60	68·07	8·89

It would seem from the preceding table, that the percentage of coke obtained was greater than the coal could yield theoretically ; the weights were, however, carefully taken, and the author attributes the yield to the fact that large quantities of deposited carbon were found in the coke.

The writer has designed and erected a battery of Semet-Solvay ovens for the Brymbo Steel Company, Limited, North Wales, and when he was conducting enquiries as to the most suitable oven for making hard metallurgical coke for use in modern blast-furnaces, and one by which it was possible to recover the bye-products, he was struck by the large output of the Semet-Solvay oven compared with all the known systems now at work.

In Durham, there are retort-ovens which take about sixty hours to coke and produce $3\frac{1}{4}$ tons of coke per charge, the coal containing about 24 per cent. of volatile matter. The Semet-Solvay oven working on Durham coal, with the same percentage of volatile matter, produced 3 tons 6 cwts. of dry coke in twenty-two hours from one charge ; or taking the production of coke in the case of the retort-ovens referred to as 1·08 cwts. of coke per hour, the Semet-Solvay gave 3 cwts. of dry coke per hour. At many works, the Semet-Solvay oven produces 1,200 tons of coke per oven per annum, and this quantity has been considerable exceeded. In our district, it is 1,440 tons per annum.

The writer is informed, however, that faster working of retort-ovens has been obtained in Durham, and that charges are now coked in from forty-eight to fifty hours ; but this still leaves a great balance in favour of the Semet-Solvay oven with regard to rapidity.

Now, is this rapidly-carbonized coke as economical when used in the blast-furnace as other cokes? It is difficult to quote facts and figures from blast-furnaces in work, as the information so obtained is generally of a private character. The writer can, however, give two instances of blast-furnaces in work on Semet-Solvay coke (they are not in any way comparative, but simply show what can be done with the coke) :—

Furnace.	Ore used per Ton of Pig Iron. Cwts.	Limestone used per Ton of Pig Iron. Cwts.	Dry Coke used per Ton of Pig Iron. Cwts.
No. 1	36·40 ...	7·30 ...	16·70
No. 2	46·00 ...	13·23 ...	20·34

These results speak for themselves. In another case, the consumption of coke per ton of pig iron was reduced nearly 2 cwts. when using Semet-Solvay coke instead of beehive coke, other things being equal.

The writer attributes the great speed of coking, large yield of coke and bye-products, and ease with which repairs can be made :—(1) to the considerable mass of the supporting-walls ; (2) to the thin sides of the channel-bricks in the heating-flues on the side nearest to the oven ; (3) to the adoption of horizontal side-flues ; (4) to the arrangement of heating-flues on each side of one supporting-wall ; (5) to the fact that the coking process is carried on in closed retorts, so designed that leakage is reduced to a minimum ; and in this way the bye-products, ammonia, tar, light oils, etc., are not lost, but are carried forward with the escaping gas and fully recovered in the bye-product apparatus : the yield of coke is also at its maximum ; and (6) to the facility for changing all parts of the ovens subject to wear and tear, without disturbing the supporting-walls or main structure of the oven.

The Semet-Solvay oven very much resembles a large gas-retort, inasmuch as it is so constructed that it is a gas-tight chamber (Figs. 1, 2, and 3) lined on either side with large channel-bricks, containing the heating-flues, which are rebated one into the other so as to break the joints. The method of construction is very substantial ; thus at Havré, near Mons, in Belgium (where the first installation of Semet-Solvay ovens was erected), they have been at work for seven years without any important repairs having been made, and they are still in an excellent state of preservation.

By adopting this method of construction, and working the ovens so that a very slight pressure of gas is always kept on the oven side (as in

gas-works practice) the admission of air into the ovens is entirely prevented, no gas is lost by leakage into the heating-flues, and no coke is wasted by combustion with the oxygen of the air.

The following is an analysis of coke-oven gas working on washed fuel (after the absorption of the benzol vapours) :—

	Percentage by Volume.
Carbonic acid gas ...	3·27
Carbonic oxide gas...	7·95
Oxygen	0·23
Hydrogen	52·77
Nitrogen	1·99
Marsh gas	31·22
Olefines	2·57

The highly heated portions of the ovens, such as the channel-bricks containing the heating-flues, are independent of the main structure, and as they have only to carry their own weight, instead of the superincumbent brick-work, they are less liable to destruction.

As the sides of the flues are thin, the transmission of heat is rapid from the burning gases to the fuel which is being coked. More efficiency is therefore obtained, and rapid coking without excessive heating also follows. The writer has found by experiment that when employing fire-clay walls to the side-flues, $2\frac{1}{2}$ inches instead of 3 inches thick, 33 per cent. more heat was conducted through the thin than through the thick wall in a given time.

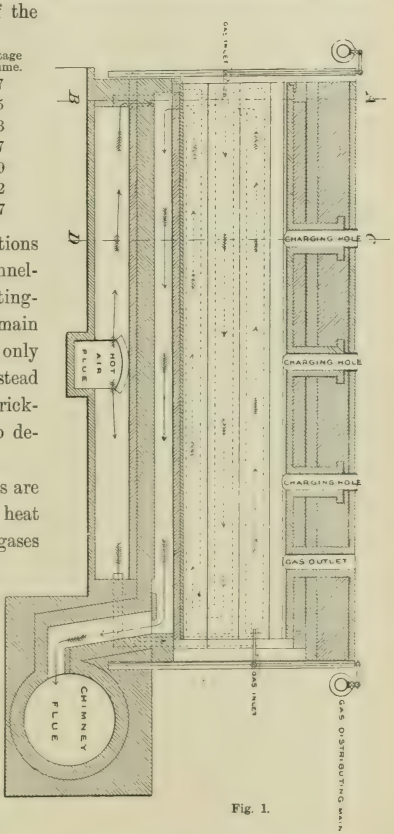
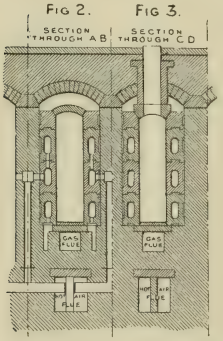


Fig. 1.

The supporting-walls between each oven also play an important part in regulating the heat. As soon as the coke is discharged from the oven,

the doors at both ends are closed, and the oven is filled with fuel as rapidly as possible. This necessarily cools the oven, but the supporting-walls, which are of considerable mass, give out their heat in the first instance to the channel-bricks, and maintain them at an even temperature. This recuperation of heat is important, or otherwise the oven would be apt to cool to some extent, and in working the ovens to obtain a good metallurgical coke, it is very important to submit the fuel to a high temperature as soon as it is charged, and that the coking process should be carried on without stoppage.



The Semet-Solvay ovens are usually built in batteries of twenty-five ovens, which makes a convenient size, and these twenty-five ovens should be discharged twenty-eight times in twenty-four hours. It is of great importance to the condensers, washers, etc., that charging should be continued, without intermission, day and night at stated intervals, otherwise the supply of gas given off is irregular, and interferes with the complete recovery of the bye-products.

The general dimensions of each oven are as follows :—Length, 30 feet; height, 5 feet 6 inches; the width varies according to the quality of the fuel to be treated, and must be determined for each particular case. For fuel containing only a small percentage of volatile matter, say 15 to 17 per cent., the width is only from 13 to 14 inches; for fuel rich in volatile matter, say 30 per cent., the width would be from 16 to 17 inches.

It is important to avoid loss of heat, in order to obtain equal distribution in all parts of the oven and to ensure the regular and rapid coking of the charge. With this object, a thick covering is placed over the chambers, in some cases as much as 4 feet thick. Sheet-iron doors are also provided to protect the cast-iron doors of the oven against the cooling influence of the weather. In this way a charge is coked right up to the fire-clay lining-bricks of the oven-doors, and no loss from half-burnt coke occurs at the ends of the ovens.

The doors are made so as to permit of easy and effective luting, and are raised from the top by means of a small hand-winch. All other openings, such as the charging-holes and the cleaning-holes in the ascension-

pipes, are closed by plates with faced joints, kept tight by springs in such a way so as to avoid the necessity of luting, and lessening the time occupied in charging.

The batches of coke, after leaving the oven, do not present any trace of wasting, which proves that the ovens are air-tight.

The gaseous products of distillation leave the ovens by the openings into the ascension-pipes and pass thence into the hydraulic-main, where the gases from the various ovens unite. The gas then bubbles through the water and liquor, from one side of the hydraulic main to the other, past the baffle-plate, and the temperature is quickly reduced, which prevents the deposit of hard tar in the pipes and recovery-apparatus. Each oven can be shut off by a valve from the hydraulic-main when being charged.

From the hydraulic-main, the gas, containing most of the tar, the ammonia, and the light oils, passes through the condensing apparatus. It is important, however, not to cool the gas too rapidly, or trouble will ensue by reason of deposits of naphthaline obstructing the pipes and recovery-apparatus and necessitating constant attention. If, however, the gas is slowly cooled, this drawback is entirely avoided.

During the cooling of the gas, portions of the tar and ammonia-liquor are condensed and run into the receiver, where they are separated by their difference of specific gravity. The tar is then pumped to the reservoir and the liquor to the ammonia-washer, as in the first instance it is too weak for treatment.

The gas, after leaving the condensers, is usually drawn away by a Gwynn or rotary exhauster, and forced towards the washers and absorbers, where the remaining ammonia and the light oils are extracted. The ammonia-liquor leaving the washer should contain 2·25 per cent. of ammonia, equal to 9 to 10 ounces liquor.

Before going any further, the writer would like to point out the benefits resulting from the use of fairly dry fuel in ovens, depending as it does on the great amount of heat rendered latent in evaporating water.

Take a battery, coking 100 tons of coal per day, and producing 19·7 cubic metres (696 cubic feet) of gas per minute. In the first instance the writer will give the number of calories to be absorbed per minute, in order to cool the gas which leaves the oven at 500 degs. Cent. down to 15 degs. Cent. on entering the exhauster, assuming that the coal is perfectly dry ; in the second place, the number of calories to be absorbed if the coal contains the normal quantity of water, viz., about 4 per cent.; and in the third case the number of calories to be absorbed if the coal contains 12 per cent. of water, which is a common percentage after washing.

Calories to be absorbed in each case per minute :—

(1) 19·7 cubic metres of gas	...	× 0·34 × 485	= 3,248	calories.
(2) 2·77 kilos. of water per minute		× 814 = 2,254 + 3,248	= 5,502	,,
(3) 8·31 kilos. ,, ,,		× 814 = 6,762 + 3,248	=10,010	,,

Consequently, if the above amount of work has to be done in cooling the gas and water-vapour, a similar amount of heat has to be expended in the ovens in raising the gas and water-vapour to the temperature named, with a corresponding consumption of fuel.

The gas, after it has been forced through the washer and the absorber, is conducted back in pipes to a distributing-main which runs round the ovens, and from this main it descends through regulators and service-pipes. The first supply to heat the ovens is burned with heated air in the top-flues on the back or ram-side of the ovens ; passing along these flues the heated products of combustion reach the front of the ovens, where they turn down and meet the second supply of gas and air in the middle flue. The current is now towards the back of the ovens, where it again descends, passing forward to the front end, and finally the heated gases from either side unite in one main-flue under the bottom of the oven, by which they are conducted into the main or chimney-flue.

The division of the gases is intended to provide against the great local heating which would take place if it were all introduced at one point, and also to apportion the heat in a more uniform manner. The air necessary for the combustion of the gases is preferably heated in flues placed underneath the hearth. This air is drawn by the chimney, and has to travel through the heated flues before it is admitted at the point of combustion with the gases in the side-flues of the oven. The heating of the air is carried to 350 or 400 degs. Cent., and in this way a part of the heat which would otherwise be lost in the hearth of the oven is recovered, and the hearths are also kept comparatively cool.

Dampers regulate the communication between each oven and the main-flue for collecting the waste gases, and they are opened to such an extent that the draught of the chimney is equal in effect upon each oven. Through the main-flues the heated gases and products of combustion are conducted under boilers for raising steam, and afterwards pass away into the chimney. The Babcock and Wilcox is a convenient type of boiler for this purpose. It is a powerful boiler with a large heating-surface, occupies a small area, and offers little or no obstruction to the draught. The writer has had these boilers at work in connexion with coke-ovens of various descriptions for over eight years, and they have

given every satisfaction. The boilers should have a heating-surface of 70 to 80 square feet for each oven at work, and the waste heat is sufficient to evaporate 0·6 lb. of water per lb. of fuel coked. If the surplus gas is also burnt under boilers, 1·25 lbs. of water will be evaporated per pound of fuel coked.

The steam recovered from the waste heat leaving the ovens is amply sufficient for the requirements of the plant and the recovery of the bye-products.

In coking rich coal two-fifths to half of the gas produced is surplus, and can be applied for various purposes. An analysis of this gas has been previously given, and from a good gaseous coal 10,000 cubic feet per ton at least is obtained.

Before the absorption of the benzol, and consequent reduction of the olefines, the gas made from fair gas-coal is sufficiently good for illuminating purposes without enrichment, having an illuminating power of 16 to 17 candles.

The illuminating power of the gas is a very good indication of how the ovens are working. If it is high, no air is being drawn into the ovens, and the yield of benzol and other bye-products is large.

After the absorption of the light oils, the surplus gas, amounting to nearly 4,000 cubic feet per ton, can be used with great advantage in steel-furnaces, working gas-engines, or for generating steam.

The writer has calculated that if Semet-Solvay ovens were added to an open-hearth iron and steelworks plant, producing both pig-iron and steel, and if 2 tons 16 cwts. of coke could be manufactured per ton of steel made, no other fuel than the waste gases would be required for the manufacture of steel, including heating and rolling. As, however, this quantity of coke would probably make 2 tons 5 cwts. of pig-iron, and as 15 cwts. only are required for making a ton of steel, the rest being composed of scrap, it would either be necessary to make and sell 30 cwts. of pig for every ton of steel made, or sell about 1 ton 16 cwts. of coke. The coke-ovens would in this case be heated by producer gas, consuming about $2\frac{1}{2}$ cwts. of small coal per ton of coke made, thus liberating the whole of the coke-oven gas.

The question of high cost has been urged against the Semet-Solvay ovens, but if the total cost of a battery be divided by the production of coke per annum, it will be found that the Semet-Solvay system is less expensive than any other recovery-plant per ton of coke produced, and the working expenses are not higher than those of the beehive coke-oven, although the cost of recovery of the bye-products is included.

The yield of bye-products from the Semet-Solvay ovens, with fairly rich coal, is about 5 per cent. of tar, 1·30 per cent. of sulphate of ammonia, and 3 gallons of light oil of a specific gravity of 0·89 per ton of coal.

The annual production of coke in the United Kingdom is probably 10,000,000 tons, representing at least 14,300,000 tons of coal. If this coal were treated for sulphate of ammonia, there would be an annual production of 181,000 tons from this source alone. So far, the demand for sulphate of ammonia has been in excess of the supply.

The exports of nitrate of soda from Chili amounted in 1894 to 1,082,000 tons, which at a value of £9 per ton makes £9,738,000. Whenever sulphate of ammonia approaches within £1 to 30s. per ton of the cost of nitrate of soda it replaces the latter for agricultural purposes, so that it will be readily seen that even if a large increase were made in the production of sulphate of ammonia, it would all be sold, and the country would retain nearly £2,000,000 annually which at present is spent in buying nitrate of soda from abroad.

The writer has personally examined coal from almost all parts of the world, and has visited all the important coal-fields. It strikes him as marvellous that with the best and richest coal in the known world, the inhabitants of the United Kingdom of Great Britain and Ireland should make so little use of the large quantity of valuable bye-products which it contains, while their foreign competitors collect and sell these bye-products.

———

Mr. S. A. Sadler (Middlesbrough), wrote that he had had seventy Simon-Carvès coke-ovens working at his Lanchester colliery, near Durham, for more than a year, producing 1,000 tons per week of first-rate blast-furnace coke. The waste heat and gases from the ovens produced sufficient steam from four Lancashire boilers to drive all the engines connected with the bye-products plant and the colliery. Each coke-oven carbonized 5 tons 10 cwts. of coal every forty-eight hours, and produced an average yield of 76 per cent. of dry coke. The coal contained, on an average, 23 per cent. of volatile matter. By the aid of recuperating-flues the air required for the combustion of the gas under the coke-ovens was heated to a dull redness. Durham coal was evidently not so rich in nitrogen and volatile matter as the coal used in the Brunck coke-oven, and could not therefore give anything like the yields referred to in Dr. Brunck's paper. The bye-products that were being obtained from the Simon-Carvès coke-ovens at Lanchester approximated very nearly to those

claimed by Mr. Darby. They were as follow:—Sulphate of ammonia, 32 lbs.; tar, 7 gallons, and crude benzol, 2 gallons respectively, per ton of coke. Together these bye-products represent a value of 4s. to 5s. per ton of coke produced. It has been found that 18 cwts. of the Lanchester coke will produce 1 ton of pig-iron; it was therefore of essential importance that the ironmasters of the district should effect this saving, in addition to the increased yield of coke, which was at least 15 per cent. above that from beehive coke-ovens. Pig-iron manufacturers in this country could not meet the competition of German makers unless they adopted similar methods of making the coke in closed ovens, by saving the bye-products, and by the extra yield of coke, otherwise the foreigner would have an advantage of at least 6s. per ton of iron.

Mr. W. Schroller (Durham), said that one of the chief characteristics of the Semet-Solvay coke-oven was the thinness of the sides of the heating flues, and they were separated by the bulky supporting-walls necessarily placed between them. In the coking of Durham coal (and it was the best coking coal in the world), it was difficult to believe that the Semet-Solvay coke-oven would give as good results as the Simon-Carvès coke-oven. The former coke-oven might certainly yield excellent results in coking dry coal, containing only 12, 14, or 15 per cent. of volatile matter, but different results would be obtained with Durham coal containing as much as 23, 24, and 25 per cent. Messrs. Simon & Carvès (now the Durham Coke & Bye-products Co.) had first introduced into this country and successfully worked bye-products coke-ovens whereby most excellent furnace coke was being produced regularly. The idea of thin coke-oven walls, he must admit, was very seductive, but nothing else; and as regards the quality of the coke produced by the Semet-Solvay, this is, with them, obviously a secondary consideration, because, as ammonia-soda manufacturers of world renown, all they care for in employing thin oven walls was: the production of ammonia. With the Durham coal owner, however, for example, the most material point was the production of good blast-furnace coke, and that has been proved by the Simon-Carvès construction by employment of thick flue-walls in daily practice and for years. He (Mr. Schroller) asked the author of the paper whether benzol can be recovered from the Semet-Solvay oven gases?

Mr. J. R. Breckon (Sunderland) thought that it would be useful if the writers of the two papers would state the quantity of bye-products obtained; for instance, the quantity of tar in gallons, and the quantity of ammonia-liquor (8 degrees Twaddle) in gallons, so that the members

could see how the saving by the bye-products was calculated. A saving of 5s. per ton was very fascinating, and seemed to point to the necessity of investigation by competent authorities, in order to impress coke-manufacturers with its importance. The quantities of coke produced by these new coke-ovens, 1,375 and 1,200 tons respectively per oven per annum, were marvellous quantities, being four times greater than the yield of the beehive coke-oven, and considerably more than the Simon-Carvès coke-oven. Mr. Darby stated in his paper that a saving of 2 cwts. of coke per ton of pig-iron had been obtained. The use of coke made in retort-ovens in the Durham district pointed to the opposite result. The application of thin side-walls for the heating-flues appeared to be right in principle, provided that the durability of the oven was not sacrificed or the cost of maintenance considerably increased. He was glad that these papers had been brought forward, for the more the subject was forced upon the attention of users of coke, the more satisfactory it would be to the colliery owners, the makers of coke, the users of coke, and all concerned.

Mr. A. L. Steavenson (Durham) desired to disabuse Mr. Darby's mind of the fact "that the question of better arrangements for the coking of coal should not have attracted more consideration." He (Mr. Steavenson) read his first paper thirty-five years ago to the Institute on the manufacture of coke, and since then the question of the best coke-oven had received his continual consideration, and that of many others present at this meeting. He had tried many kinds of coke-ovens, but he still continued to work the old round beehive coke-oven. Mr. Darby stated that the Semet-Solvay coke-oven produced 80·5 per cent. of dry coke when burning Durham coal; but the best Durham coal did not contain so much. In an analysis made by Mr. John Pattinson he found that the fixed carbon was 68·74 per cent., and the volatile hydrocarbons 27·06 per cent. It was evident that Mr. Darby had produced unfinished coke, the coking process had not been completed, and (he supposed) the volatile hydrocarbons were remaining to a large extent in the coke. If the volatile hydrocarbons were left in the coke there was a considerable diminution of the work done by the coke in the blast-furnace. In all retort-ovens the coke must be withdrawn and watered afterwards, and the coke instead of containing only 0·4 or 0·5 per cent. of moisture contains as much as 4 or 5 per cent. Neither of the writers referred to the mechanical structure of the coke. At a colliery, in Durham, out of a possible 68·74 per cent. at least 64 per cent. of beautiful coke was produced, and in addition the waste gases heated all the boilers, pumped

all the water, and drew 900 tons of coal per day from a depth of 600 feet If they were able to produce first-class coke and do all that work in addition, they had every reason to be satisfied.

Mr. T. W. Benson (Newcastle-upon-Tyne) presumed that Mr. Darby had been treating of coke entirely used at home for the special purposes required by the firm who made the coke. He would like to know whether the coke had been offered for sale in the open market, either for use by other people at home or for export. His experience of coke made from other than beehive coke-ovens was that it did not give satisfaction when sent abroad. About twenty-five years ago, in order to increase the produce of coke, his late father and himself applied bottom-flues and side-flues to circular beehive coke-ovens. The result was fairly satisfactory, as the ovens were burnt off in forty-eight as easily as in seventy-two hours, but the coke was formed in two distinct layers. There was a distinct fracture about mid-height in the coke, producing four instead of two "black-ends," and the coke was not so readily sold as the bright silvery product of ordinary beehive coke-ovens. In 1873, when coke was in great demand, he erected twenty rectangular coke-ovens, from which the coke was drawn in a body by means of an iron anchor and winch. The result was similar to the experience related by Mr. Steavenson, the coke was saturated with water, and had a tendency on being brought out of the oven to re-light and fire, causing an ash on the surface. The mechanical condition of the coke was not so good as that produced in the ordinary beehive coke-oven.

Mr. W. Cochrane (Newcastle-upon-Tyne) said that twenty-five or thirty years ago he adopted a Belgian oven similar in type to the Semet-Solvay coke-oven, with a rammer for driving the coke out of the oven, and of the entire plant no remains were now left. The thin side-flues of the Semet-Solvay coke-oven were a source of weakness, and would speedily be destroyed with the removal of the coke. The coke would not be fit for blast-furnace purposes; its formation starting simultaneously from the bottom and sides, yielding a large quantity of breeze at the lines of separation and decreasing the percentage of valuable coke. The coke could not be cooled inside without considerable damage to the oven; therefore the coke must be withdrawn and watered outside, and would contain a large amount of moisture. All the various types of ovens, vertical and horizontal, had been adopted in the Durham district, but they had not found anything to equal the beehive coke-oven for the class of coal they used.

Mr. H. A. Humphrey said that he had seen the Semet-Solvay coke-ovens working on the Continent, in America, and had for the last few

years had a number of these coke-ovens under his charge. Messrs. Brunner, Mond, & Co., Limited, have at Winnington two batteries or a total of thirty Semet-Solvay coke-ovens. The primary object of these ovens was to make good coke and not, as Mr. Schroller had suggested, to recover the ammonia, although the latter was a most valuable product. At the present moment twenty-five ovens were at work, 109 tons of slack were coked per day, and thirty-one of these ovens were discharged per day. These ovens had been worked for weeks continuously at a coking-rate of less than nineteen hours per charge, a speed which compared favourably with any results of other coke-ovens. The extra temperature required for perfect coking at this speed of working was perhaps a drawback, and the rate first mentioned was to be preferred. The yield of coke was 80 per cent. on the slack, the coke containing 4 or 5 per cent. of moisture, an excess of water in quenching the coke when it leaves the ovens being used, as it is immediately filled into wooden waggons. He regretted that his experience did not extend to the use of Semet-Solvay coke for metallurgical purposes. At Winnington, the coke was used for burning limestone, and for this purpose a coke containing more ash was permissible. Washed slack, containing a large per cent. of moisture, had been used most successfully, but owing to the extra cost a cheap slack of the following analysis was now used:—

	Per Cent.
Moisture	$2\frac{1}{2}$
Volatile matter	23—27
Ash	12—16
Nitrogen	1·3

Owing to the high temperature of coking extremely little volatile matter was left in the coke. The quantity of gas produced had been underestimated by Mr. Darby. The quality of the gas produced at Winnington was shown by the following mean results of daily aspirator-samples taken during a month:—

	Per Centage by Volume.
Carbonic acid gas	3·0
Olefines ($C_n H_{2n}$)	3·1
Carbonic oxide gas (CO)	8·8
Hydrogen (H)	56·0
Marsh gas (CH_4)	23·7

or 91·6 per cent. of combustible gases; and with slightly less draught on the hydraulic main these results might still be further improved. The yield of ammonia was extremely regular and apparently depended little on the quality of the slack. The cooling plant was of insufficient capacity for summer work, but taking summer and winter together an average of 0·3

per cent. of ammonia on the slack was obtained; that was 1·2 per cent. of sulphate, equal to 27 lbs. per ton. The coke, so far from being soft as suggested by Mr. Cochrane, left the ovens in a long solid wall, and three men with rakes were required to pull it flat on the ground for quenching. By the use of a bubbling main there was no difficulty whatever with the formation of hard tar, and the cleaning of the plant was reduced to a minimum. The coolers and coke-scrubbers were not cleaned more frequently than once a year. Mr. Darby had made a passing reference in his paper to the use of coke-oven gas in gas-engines. He would like to point out the relative value of this gas as compared with good coal-gas and Dowson producer-gas:—

1 cubic foot of good coal-gas yields 680 units of heat.
1 „ „ of coke-oven gas „ 510 „ „
1 „ „ of Dowson gas „ 160 „ „

The position which the coke-oven gas holds was clearly shown by these figures, and he might mention, to prove the quality of this gas, that it constituted 75 per cent. of the illuminating-gas used throughout the large works and the village at Winnington. The other portion of the surplus gas from the ovens was burnt under steam-boilers, as described in the paper.

Mr. B. Dodd (Durham) enquired whether the Semet-Solvay coke-ovens were drawn out at regular intervals night and day or in the day-shift only, as this would make a considerable difference as to the condensing-plant required? He would also like to know the height of the blast-furnaces in which the coke had been tried?

Mr. L. H. Armour (Gateshead) wrote that, after listening to Mr. Darby's paper on the Semet-Solvay coke-oven, he felt constrained to review one or two points raised by that gentleman. From personal contact with many coke-makers in various parts of the kingdom and inspection of their methods of working, he was prepared to say that they were not only anxious for improvement in their processes, but that they were ready to spend money to prove any matter likely to advance their interests. He thought that even the simple beehive coke-oven demanded, at most collieries, judgment and readiness of resource that were very far from the description "no great skill." The Durham coke-maker aimed at producing fuel suitable for the work of the modern blast-furnace. To this end it was essential that all the volatile matter should be expelled; and that this was secured by the beehive coke-oven there was no attempt to question. Burning from the top of the charge as the fire descended in a beehive coke-oven the gases from below are obliged to pass through the upper incandescent layer, and in passing they

are decomposed, the coke being thereby coated with hard carbon. This goes on until the charge is glowing all through, and this thermo-deposition of carbon at a high temperature gives the coke the much-desired silvery appearance. The writer, having conducted a number of experiments to test this thermo-deposition of carbon, it might be of interest to give some of the facts. Among the coal to be coked in a beehive oven were placed boxes containing articles of earthenware, say, 12 to 15 inches, below the top of the charge. These articles, of course, underwent the full heat of the charge, and met the rising currents of gases, and, when the charge was drawn, were found coated with carbon of the thickness of 0·02 inch and more. Strips of this deposited carbon subjected to a high electric current split into layers of gossamer fineness, being no doubt parted in the same way as they were deposited. The hottest part of a coke-oven is the charge, and the greater the heat the better will be the texture of the deposited coat. Let them consider for a moment the action of a gas retort. The most highly-heated part is the retort, and the hottest part of the retort is that on which the fire strikes, usually the bottom; hence the coat of carbon-scurf which forms on the inside by the thermo-deposition of carbon, and as the retort attracts to itself this carbon, the coke is left comparatively free from this deposit, therefore it is dark, as compared with coke made in a beehive oven. Mr. Darby has told us that "the Semet-Solvay oven very much resembles a large gas-retort," and its effect on the coke will also have some analogy. This statement is borne out by the darker appearance of the coke produced. Mr. Darby dwells upon the short time required to carbonize each charge in the Semet-Solvay oven, but this extreme hastening has another side, as the gases are driven off so rapidly and from all parts alike, that even were the coke in a state to take on a crust of hard carbon, there is very little opportunity for it, nor are the conditions otherwise favourable.

Dr. P. P. Bedson, in reply to a remark made by Mr. Sadler respecting the yield of tar and of ammonia obtained with the Brunck oven, pointed out that Dr. Brunck stated the ovens to yield 13·4 per cent. of tar more than the Coppée-Otto oven, and 9·5 per cent. of sulphate of ammonia more than the Coppée-Otto oven.

The President moved a vote of thanks to Mr. R. Brunck and Mr. J. H. Darby for their interesting papers, and the discussion was adjourned.

The following paper by Mr. B. H. Thwaite on "Engineering Heliography, or the Sun-print Copying of Engineering Drawings" was taken as read:—

ENGINEERING HELIOGRAPHY, OR THE SUN-PRINT COPYING OF ENGINEERING DRAWINGS.

By B. H. THWAITE, C.E., Fellow of the Royal Photographic Society.

Introduction.

Since the appearance of the author's contribution to the *Minutes of Proceedings* of the Institution of Civil Engineers, entitled, "Heliography, or the Actinic Copying of Engineering Drawings,"* published some nine years ago, this rapid, accurate, and scientific method of reproducing engineering and architectural delineations has become exceedingly popular, and there are very few first-class engineers' drawing offices without some form of heliographic equipment. When this first paper was read, the number of engineering ateliers in which heliographic methods were utilized was exceedingly limited.

Engineers readily acknowledge that this scientific expedient has been of great advantage to them, both on the score of cost of production, and on the more important one of absolute fidelity of reproduction. The characteristics of the heliographic process are so important that its rapid popularization is not at all surprising. Heliography, properly understood and practised, enables the reproduction of dimensioned, mechanical, geometrical, or freehand-drawing delineations to be made with absolute fidelity to the original. Heliography, under favourable sunlight or actinic conditions (actinicism meaning the chemically acting energy of direct or diffused sunlight), enables the most elaborate and detailed drawing to be reproduced in a small fraction of the time that would be absorbed in mechanically re-copying the original delineation.

Heliography permits the reproduction of an almost unlimited number of copies: it also enables by mere manipulation the production of a full-size elevation, plan, or section, from a half-drawn tracing, whenever such half-section is equal and alike in all particulars to the full section when drawn in duplicate. If the original or traced figure to be produced is figured partly on one side and partly on the other, or on the face of the tracing, this imperfection is not observable in the heliographic copy.

* Vol. lxxxvi., 1885, page 312.

Heliography possesses other advantages that may be appreciated from a commercial side, for instance the facility with which manufacturers and merchants can obtain copies of tracings lent to them for the preparation of estimates; this rapidity of the heliographic system has permitted manufacturers and merchants to tender or submit prices, at extremely short notice, who, probably, would not, but for this facile process, have had the opportunity of doing so.

Large drawings can also be built up of sheets reproduced by the heliographic process in a most satisfactory manner.

Drawing Office General Procedure.

The Preparation of the Original Tracing.—The following procedure is possible, as a consequence of the adoption of the heliographic copying method.

Instead of completing original drawings by inking them in, accurate tracings can be made, to serve as the office negatives; if alterations are made on the original drawings, new tracings can be made and marked and numbered, the original drawing being in pencil can be easily altered, whilst a comparison between the two tracings will immediately show the extent and character of the alterations, and the confusion often exhibited in an original drawing that has been altered, is thus avoided.

Besides, the new tracings would not show any obscurity or indefiniteness, and if marked consecutively and carefully dated, would show when the alteration was decided upon.

If the tracings are carefully preserved, they will form a record of the work as carried out. Each tracing should be accompanied by a heliograph (which should serve for use in the drawing office), in addition to the several duplicates required for the workshops. The tracing itself should be carefully kept, uncreased and unsoiled, for special reference, and for heliographic purposes.

The author does not intend to describe all the various heliographic formulæ, because a reference to his previous paper will enable the student to follow up the subject more exhaustively. The author will confine his remarks to a description of those processes that have won their way to popularity by the action of the law of the survival of the fittest.

Outline of Procedure.—The practical art of heliography or sun-drawing is simplicity itself. The procedure may be divided into three divisions. (*a*) The preparation of the original delineation or figure on translucent material, such as tracing-paper or tracing-cloth. (*b*) The application of a special and actinically-sensitive

paper to the face of the traced delineation to be reproduced. (*c*) The exposure of the delineation, with its accompanying actinically-sensitive paper to the effect of actinically active daylight, or in other words, to the effect more or less direct of solar light, or its near equivalent, such as an electric arc-light, of which the luminous rays have associated actinic or chemically active energy. It may here be stated that with electric arc-lights of 6,000 candle-power, both the Pellet (which requires half an hour) and the other cyanide papers can be actinically printed. (*d*) The removal of the sensitive paper, after adequate exposure to the influence of actinic or chemically active light, to the developing solution. (*e*) The application of the adequately exposed sensitive paper to the effect of the developing solution, for a sufficient time and in a proper manner, so as to leave on the surface of the sensitive paper, a distinct or well-defined, and more or less permanent, but absolutely accurate reproduction of the original delineation.

Outline Description of Heliographic Equipment.—To effect these five different processes peculiar to all methods of heliographic reproduction, an equipment of the following character is required:—(*a*) Tracing on translucent paper of a suitable character; (*b*) the actinically sensitive paper; (*c*) the printing-frame, by which the sensitive paper is exposed to the influence of actinic light; and (*d*) the developing-bath or baths by which the figure is permanently fixed.

Detailed Description of Heliographic Equipment and Agents.—A detailed description of the equipment as classified may now be given.

Tracing-papers.—The translucent character of the tracing-paper or cloth is of first importance. Strong yellow-tinted paper is not only unsuitable for rapid effect, but is inimical to accuracy of reproduction, because unless the rays of light falling on the plane of the glass of the printing-frame are directly at right angles to it, the thickness of the tracing paper tends to produce a distorted and indefinite image.

Special thin blueish-white, or almost white parchmented and alkaline papers, highly translucent, and only tearable by somewhat violent tension, are now manufactured, and are undoubtedly the ideal paper for heliographic use. The cost of such paper of thin alkaline quality, and for lengths of 66 feet by 30 inches wide, is 0·144d. per square foot, while a better quality costs 0·28d. per square foot.

After use, the tracings should, as far as possible, be preserved from sunlight, because by actinic and chemical action of light the paper is apt, not only to lose its transparency, but also to become brittle, and white, opaque creases and lines are the result of its being folded.

It is not advisable that the tracing should be folded, because the folds not only tend to destroy the translucency, but they make it more difficult to obtain a close contact between the tracing and the glazed surface (glass) of the printing-frame. The importance of a close contact although obvious, may be thus enunciated; wherever a tracing is in imperfect contact with the sensitized surface, the light-rays flow beneath the opaque lines of the drawing, and there is consequently no reproduction within the area of contact-imperfection.

If the tracings are required to be rolled, they should be wrapped around stiff cardboard or wooden rollers at least $1\frac{1}{2}$ inches in diameter, and carefully stored in positions removed from actinically active light.

Translucent Drawings.—Ordinary drawing-paper can be made temporarily translucent by immersion in benzine, but in order to permit of its use for heliographic reproduction a rapidly sensitive character of paper must be employed. Special translucent parchment drawing-paper suitable for heliographic reproduction can now be obtained.

It is always advisable to cut the heliographic paper which is to be actinicized, of a size slightly larger than the tracing, so that its margin protrudes from under such tracing ; the effect of the actinic light on the exposed paper will be a measure of that under the tracing, being, of course, slightly less under the tracing, and in a degree depending upon the translucence of the latter.

The Printing-frame.—This part of the heliographic equipment permits of the sensitive paper being placed in contact with the figured tracing, under the influence of actinic light.

The degree of success in the process of heliography greatly depends upon the merits of the printing-frame. The apparatus should possess the following qualifications :—

It should permit the operator to place the figured tracing rapidly in position, and in close and equal contact, effected by well distributed pressure applied over the entire surface of the tracing. If the pressure by which the tracing and sensitized paper are brought together, is local in its effect, irregularities and false impressions are produced, besides which the wrinkles and creases produce shadows on the heliograph copy.

It is advisable to employ at least two sizes of printing-frames, one of which shall be large enough to permit the exposure of double elephant copies, 30 by 43 inches, the other and smaller are to be sufficient for taking royal copies, 19 by 26 inches.

When larger copies than the frame can take are required, a line in pencil should be drawn across the tracing so that the heliograph can be

copied in sections, which are afterwards fastened together with gum or any other suitable translucent medium, at the line of connexion. The author has obtained excellent and very large copies in this way.

The structural characteristics of the printing-frame itself are simple enough, and will be understood from the drawings of different types submitted, and from the actual examples exhibited.

The glass of good plate quality, free from blows, streaks, and all blemishes, either of inequality of thickness or of translucency, should be at least, for the double elephant size, $\frac{1}{4}$ inch in thickness, while for the smaller frame $\frac{3}{16}$ inch plate-glass may be employed.

In order to equalize the pressure of the backboard on the surface of the tracing and sensitized paper, thick, soft felt, at least $\frac{3}{8}$ inch thick, or a piece of trebly-folded flannel, will satisfy requirements. Indiarubber sheets, the full size of, and attached to the edges of the felt or flannel, will improve the equalizing action of the felt.

The edge-frame should be as strongly proportioned as convenience of portability will permit, and be rebated so as to carry the plate-glass and the considerable pressure brought to bear upon its surface.

The backboard of well-seasoned wood, if not in separate parts, should be stiffly constructed and well bound up. It should have two handles to facilitate handling. If the backboard is in separate battens, the centre batten should be the first to be applied—each batten to have its clamping-down springs. There are several methods of clamping-down the backboard to the felt. The pressure is principally applied by steel springs, either flat, helical, or coil.

In the Street printing-frames, an air-cushion is attached to the frame, and by mouth-blowing both an equable and a considerable pressure can be produced.

The author's method of mounting the printing-frame is shown in Figs. 1 and 2 (Plate III.). This arrangement enables the frame to be swung round at any angle, and to be reversed when placing the tracing and sensitized copy in the printing-frame.

The glazed frame is also available, and is not uncommonly used in the author's drawing office for tracing direct on to parchment or drawing-paper. A powerful light is placed beneath the inclined glazed surface, on the other side of which is the figured paper. The light passing through the glass and drawing enables the draughtsman to trace the figure on to the drawing or parchment-paper direct.

Methods of Exposing Printing-frame to the Influence of Actinically Active Light.—The printing-frame is mounted on special bearings, and is

easily moved about. The details of these bearings are shown in Figs. 3 and 4 (Plate III.).

When rapid effect is desired, and when circumstances admit, the Allott and Jones arrangements shown in Figs. 5 and 6 (Plate III.) can be adopted. Another arrangement for bringing the frame into proper exposure or so as to get the direct rays from the zenith, where only attic lights are available, is shown in Fig. 7 (Plate III.). The frame is hoisted up to the inclined glazed part of the roof or fan-light, counter-balancing arrangements being adopted to facilitate the raising of the frame to the desired position.

When at all convenient, the arrangements shown, or any others that permit of exposure in the open air, are undoubtedly the best. Glazed windows absorb much of the actinic energy of sunlight. The ideal position is to so incline the frame that it may face the sunlight at right angles, in order to obtain the direct rays from the zenith. When direct light cannot be obtained, recourse can be made to the Hayward or other forms of street-area reflecting-mirrors. Fig. 8 (Plate III.) shows the Thwaite printing-frame associated with reflecting-mirrors.

Of course it is not absolutely essential to expose the printing-frame in the open air. The author has obtained hundreds of copies with the printing-frame placed inside the office.

When electric arc-lights are employed, the printing-frames may be placed in a circle around the light, some 6 feet distant from it. The best arrangement for applying the arc electric-light for actinic printing is that adopted by Mr. W. H. Stanley, London, and is diagrammatically shown in Fig. 9 (Plate III.). Three printing-frames are arranged within a distance of 2 to 3 feet from an arc-lamp, and in order to obtain an equal light-diffusion, condenser-lenses are suspended from the casing of the arc-lamp. The current used has a pressure of 50 volts, and the quantity of energy is equivalent to 50 ampères. With an arc-light of this intensity satisfactory ferro-gallic (black and white) copies are obtained, with an exposure of about 3 hours. The necessary arc-light exposure when using ferro-prussiate papers is less, not more than $2\frac{1}{2}$ hours being required to obtain satisfactory prints.

On Placing the Tracing in the Printing-frame.—The *modus operandi* is simply as follows:—The figured tracing to be copied is placed with its figured surface next to the glass of the printing-frame. The sensitized paper, with its actinically sensitive or prepared surface next to the tracing is carefully and uniformly pressed into contact with it. The felt is now laid carefully upon the paper, and in such a way as not to disturb the

position of either the tracing or the sensitive paper. The backboard is then placed on to the felt, the clamping-bars are fixed in place, and gradually screwed, or, by means of springs, pressed down, so that the two papers are uniformly pressed against each other, creases or crumples not being permitted.

No obstacle, such as a mullion or sash of a window, should be allowed to intervene between the (actinic) light and the printing-frame. The shadow of such an obstruction would distinctly mar the heliograph copy produced.

Cutting and Placing the Sensitized Paper.—With the ordinary ferro-prussiate process paper in which the figure is delineated in white-lines on a blue-ground no special anti-actinic precautions in cutting the sensitive paper and placing it into the frame need be observed. If the paper is rapidly removed from its case, and cut with its face on the glass of the printing-frame (sensitive face downwards) it will not be affected by the momentary exposure to the diffused light of the office.

With very sensitive papers it is advisable to remove them from their case and apply them to the printing-frame in non-actinic light. The author has for many years used ordinary yellow window-blinds with success; but if a permanent non-actinic effect is desired the windows should be glazed with ruby or amber-coloured glass, or be covered with yellow or amber-coloured "glacial" papers.

The Direct Procedure for Producing Different Heliographic Effects.

The various chemical formula for producing the different sensitizing surfaces are given in the Appendix. It may, however, be said that the different sensitized papers are produced so cheaply by manufacturers making a speciality of this class of paper that there is little, if any, economy in the individual preparation, and especially is this so with the Shawcross ferro-gallic paper. This paper can only be produced by special machinery, and as an example of the manner of approaching this subject by two industrial nations, it is a fact that this paper is being principally made in Germany. The inventor was not able to find a British manufacturer willing to provide the proper machinery, and abandoned his patent rights.

Outline of Various Processes in More or Less Regular Use.—The different processes may be taken in the following sequence:—(1) The production of a white-line reproduction on a dark prussian-blue ground by the ferro-prussiate process; (2) a dark prussian-blue line reproduc-

tion on a white-ground, the ferro-cyanide or Pellet process ; (3) an ink-black line reproduction on a white-ground, the ferro-gallic or Shaw-cross process ; (4) a black-line reproduction on a white-ground, the melagraphic, a private, process ; and (5) a white-line reproduction on a black-ground, the platinotype process.

Suggested Specification for Sensitive Papers.—In ordering actinically-sensitive papers, the following are the necessary requirements :—(*a*) To be of a high degree of sensitiveness ; (*b*) to have excellent keeping qualities under proper conditions of storage and climate ; (*c*) guaranteed permanence of the heliographic reproduction ; (*d*) to be workable in any weather ; and (*e*) to be easy of manipulation.

Specimens of various heliographic processes are shown in Plate IV., Figs. 13, 14, 15, and 17 being printed by Messrs. Allott and Jones, of Liverpool, and Fig. 16 by Mr. J. R. Gotz, of London.

(1) *White-lines on Blue-ground (Ferro-prussiate) Process.*

Quality of Paper.—A satisfactory quality of paper should not, when folded, exhibit white creases at the folds. Ferro-prussiate prepared cloth must be preserved from the light, and even be cut in non-actinic light.

Cost.—Workshop paper, good and strong, 32 feet by 40 inches, costs 0·577d. per square foot. Extra thin, for foreign postage and for producing second and positive copies, 32 feet by 40 inches, costs 0·975d. per square foot. Ferro-prussiate calico, 32 feet by 30 inches, costs 1·278d. per square foot. Extra-rapid effect, or extra-sensitive paper is 30 per cent. more costly than the slower and less sensitive papers.

Exposure.—The length of exposure in the printing-frame depends, of course, upon the sensitiveness of the paper, the average times being :—

	For super-sensitive rapid papers.		For slow or only moderately sensitive papers.
In bright sunshine...	3 to 7 minutes.	...	15 to 20 minutes.
In diffused daylight,			
fair weather ...	5 to 10 „	...	20 to 30 „
dull weather ...	15 to 30 „	...	1½ hours to 2 hours.

With rapid or super-sensitive paper, special care should be taken in watching the exposure ; the lines of the figure on the completion of the exposure should appear in a light tint, whereas with the slow-acting paper the lines should appear of a bluish-black colour.

Colour-changes.—The colour-changes under exposure to actinic light influences are : —

1st	colour-period,	before	exposure, yellow.
2nd	,,	after	,, greenish-yellow.
3rd	,,	,,	,, greenish-grey.
4th	,,	,,	,, bluish-grey.
5th	,,	complete	exposure, olive-blue colour with metallic reflections.

The more powerful the actinicism of the light, the darker the olive-blue colour resulting from the complete action.

Development.—The completely-exposed sensitized paper should be removed from the printing-frame and be vertically immersed in water in the Thwaite vertical-bath, in the manner shown in Fig. 10 (Plate III.), or if the horizontal type of bath be used, the water should be applied with a rose, allowing the effluent flow from the prints to be continuous. The sensitized surface that has been preserved from the actinic light is washed off, leaving the figure in pure white lines. The print is then removed to dry, being hung by the side of the vertical bath or from a cord-line. By the use of blotting-paper the action of drying may be accelerated.

By employing water heated to 90 degs. Fahr. in the bath the development is more rapid and more complete. Evidence of under-exposure is shown after washing by the paleness of the blue-ground, and of over-exposure by the imperfectly white and tinted blue-lines.

By a simple adaptation of the ferro-prussiate procedure blue-line figures on a white ground can be obtained.

Ferro-prussiate Blue-lines on White-ground Procedure.—A specially thin kind of sensitized paper is used to obtain a negative or white-lines on blue-ground copy. This thin paper is similar to that employed for foreign postal purposes, and can be obtained in lengths of 32 feet at the price of 1·33d. per square foot.

This negative heliograph copy is then, and instead of the tracing, placed in the printing-frame, and another piece of sensitized paper is placed with its sensitive surface in contact with the figured side of the negative, or in the contrary position to that adopted in the tracing procedure, in which the figured tracing is placed next to the surface of the glass of the printing-frame. The time of exposure is, under identical conditions of actinic influence, four times greater than is required in the first or negative procedure.

In washing the ferro-prussiate prints, where the Thwaite vertical-bath is not available, an ordinary indiarubber tube should be provided, so that the water may be delivered over the entire surface of the paper; if the pressure be strong enough the use of a brush will not be required. The improper use of a brush will destroy the integrity of the lines.

(2) *Blue-lines on White-ground (Ferro-cyanide or Pellet) Process.*

Paper.—Mounted or unmounted paper can be obtained.

Cost.—Calico-mounted paper in 32 feet lengths, 30 inches wide, costs 2·30d. per square foot. Stout paper in 32 feet lengths, 30 inches wide, costs 1·05d. per square foot, and 40 inches wide, costs 1·015d. per square foot.

Exposure.—In the highly actinic sunlight of springtime, 20 seconds ; dull or indirect light, 2 to 3 minutes ; winter light, 5 to 30 minutes.

The exposure should be checked as follows :—Take six slips of the sensitized paper, each slip is then to be placed behind tracing-paper slips, on which lines as delicate as those on the tracing have been marked, and on an identical character of tracing-paper. The slips are then placed in a small printing-frame with a backboard, having as many hinged partitions as there are slips, and exposed to the same conditions of light as in the large printing-frame. During the exposure, the slips can be examined to test the position of the colour-changes.

Development.—Pellet sensitized paper, on removal from the frame, may be kept for several days, if it is not convenient or desirable, on account of absence of actinic light, to effect immediate development.

The exposed paper should be transferred to a saturated solution of ferro-cyanide of potassium (3 ounces of yellow prussiate to each quart of water). This solution should be contained in a guttapercha-lined tray. The exposed paper should not be immersed in the developing-solution in such a way that the solution reaches the back, but floated with its sensitive surface in contact with the solution. This may be easily done by turning up the edges of the exposed paper, which we will in future refer to as the heliograph or print. The print should be exposed to the solution for 40 seconds.

After the completion of the development, the print should be floated face downwards upon clean water in an acid bath composed of 8 parts of hydrochloric acid and 3 parts of sulphuric acid to 100 parts of pure water, say 3·6 ounces of hydrochloric acid and 1·2 ounces of sulphuric acid to each quart of water ; an alternate formula being 5 ounces of sulphuric acid to one gallon of water. The acids should be mixed together in an earthenware vessel, and be poured into a second tray and guttapercha-lined bath. From 6 to 8 minutes is adequate to allow for the acid reaction on the iron compounds, and for the removal of the redundant iron compounds by the acid solution.

If the fingers are stained in the developing process, the colour can be removed by washing them in a diluted alkaline solution of caustic soda

or potash. In order to prevent the staining of the hands or discolouration of the prints during manipulation, it is a good plan to wear white cotton gloves.

In order to ensure uniform contact with the solution a camel's hair brush should be carefully pressed over the back of the heliograph print, so as to expel the air-bubbles.

If the ground of the Pellet copies is not quite free from blue discolouration, it may be effectually bleached in the summer months by being exposed to a 4 per cent. solution of sulphuric acid; in the winter months the solution may be strengthened up to 6 per cent. of sulphuric acid. Properly exposed, perfect development has been obtained if the lines appear in dark blue on the original yellow ground.

Although Mr. Shawcross has a just claim to be considered the pioneer of the ferro-gallic process, which will be described further on, he strongly recommends the Pellet procedure and formulæ. He has made use of this process for many years, but he adopts a slight deviation in the developing process.

Pellet copies, properly washed and mounted, make admirable drawings, and this process was extensively used by the late Count de Lesseps in his engineering ateliers. They leave nothing to be desired on the score of permanency, as the examples of Lesseps' drawings shown by the author proved.

Special Method of Development.—Mr. Shawcross' modified method of developing will be understood by reference to Fig. 11 (Plate III.). A drawing or other plane board, *a*, of suitable size is inclined slightly from the vertical against the uprights *b*, which may be placed against a wall *c*. The exposed sensitized paper or print is pinned on to the board with its sensitive side on the upper surface. An enamelled metal and spouted vessel, *d*, is used for containing the solution of ferro-cyanide of potassium (yellow prussiate) in the proportions already described. The solution may be heated, and is poured over the surface of the paper in all parts, and the development takes place forthwith. The solution flows to the lower end of the board, where it is caught by the trough *e*, which is inclined towards an escape-pipe or tube *f*, into which it flows, and descends to the brown earthenware vessel *g*, provided with a cover *h*, so as to prevent the incursion of dirt or liquids. The vessel, *g*, should always be maintained full of a saturated solution of ferro-cyanide (yellow prussiate of potash) of which crystals are shown at *i*.

The advantages of this method of development may be summarized as follows:—(*a*) The developing process is visible; (*b*) the developing solu-

tion can be heated to a temperature appropriate for the season of the year; (*c*) less space is occupied; and (*d*) the cleanliness of the developer and the recovery of the used solution.

If the lines of the print during development have a tendency to spread, it is evident that the developing solution is a little too strong, or that the exposure has been inadequate. If the lines are imperfect in continuity, that is evidence of over-exposure.

Final Washing.—After the print has been exposed to the acid solution, it should be thoroughly washed, as described, for the ferro-prussiate process.

For making alterations in copies made by the Pellet process, a solution known as blue-solving is sold by manufacturers.

The acid bath may occasionally be cleansed with a potash dissolving solution.

(3) *Black-lines on White-ground* (*Ferro-gallic*) *Process.*

Since the author first introduced this process (invented by Mr. Shawcross) great improvements have been effected in its manufacture, and although the formulæ are given in the Appendix, nevertheless, except for research purposes, the author does not advise individual attempts to make this paper. Thanks to the intelligence of German manufacturers, satisfactory ferro-gallic paper can now be obtained from English stationers.

Paper.—It is a good precaution, the night before the paper is required to be used, to uncoil such part of the roll of paper as will be cut, as a better, denser, and stronger colour-tone will then result.

Cost.—Thin quality of paper in 32 feet lengths, 30 inches wide, costs 1·05d. per square foot; medium quality costs 1·05d. per square foot; thick quality costs 1·27d. per square foot; and mounted on calico, it costs 2·7d. per square foot.

Time of Exposure.—The colour-changes are: First period, before exposure, yellow; second period, after exposure, fainter yellow; third period, after exposure, still fainter yellow; fourth period, after exposure, white ground. The tint disappears, leaving the figure or delineation in the original yellow tint.

The exposed paper or prints may be stored in cases for subsequent development for as long a period as ten hours. If the exposure is not completed by the time the colour has set, it may be allowed to remain in the frame until the following morning, when the exposure can be extended to completion.

Development.—It is advisable, although not necessary, to submit the surface of the print to water-contact before exposing it to the developing influence, and this prior water-contact influence increases the density of the lines.

The developing-solution is composed of 40 grains of gallic acid per 1 pint of water. It should be stored in a guttapercha-lined bath. Another developing proportion is $\frac{3}{4}$ ounce of gallic acid (mixed in earthenware vessels) per 1 gallon of water. The solution can be employed several times. The solution will be serviceable for a longer period, if the development be deferred until some hours after the removal of the print from the printing-frame.

Immediately the print is placed in the solution (if tepid, so much the better) the yellow lines will become a very dark violet-black. It is also desirable to subject the printed surface after development in the gallic acid solution, to contact with clear water for five minutes, or until the print has no colouring influence on the water.

If the print after development is not quite white, but violet tinted, it is evidence of under-exposure, whereas if the lines are not black the print has been over-exposed. The prints can be hung to be air-dried. Ferro-gallic prints can be treated exactly as if they were drawings.

(4) *Black-lines on White-ground, Melagraphic Paper* (*the Marion Process*).

Paper.—This paper is probably based on the ferro-gallic process, but only requires pure-water development.

Various qualities of paper are produced, including a linen-mounted one.

Cost.—The paper, in 32 feet lengths, 30 inches wide, costs 1·50d. per square foot, and 40 inches wide, costs 1·52d. per square foot.

Exposure.—The exposure is similar to that described for the ferro-gallic procedure.

Development.—The face of the print should be carefully brought into close and complete contact with the developing-solution, which, for this paper, is pure water. The contact should be effected without disturbing the water, otherwise the lines of the figure will appear to be broken. The heliograph print should be left undisturbed in the water for half a minute. The print may then be brushed over with a soft camel-hair brush and hung up to dry. The water, after a minute's contact with the heliograph print, will become highly discoloured.

The print should be removed from this bath to another, in which a steady flow of water from an indiarubber tube is directed over the surface of the print.

Drying.—It is best to allow the print to dry, by being hung up and exposed to simple air-evaporation.

(5) *White-lines on a Black-ground, the Platinotype (Willis) Process.*

This process is only recommended for reproducing small drawings. It gives most exquisite and permanent reproductions, and it is also very sensitive.

Cost.—The cost of the paper, except for special application, precludes this beautiful process from being generally used. The price per 24 sheets, each 20 by 16 inches, may be reckoned at 1s. per square foot.

Exposure.—The entire process with this paper must be carried on in obscure and non-actinic light. A few minutes' exposure to ordinary daylight is adequate, and should be carefully watched.

The colour-changes are as follows:—First period, before exposure, yellow; second period, after exposure, pale greyish-brown; third period, after exposure, dull-orange hue. The last colour-change shows that the iron compounds have been reduced.

Platinotype prints need not be immediately developed, but they should be preserved from moisture by being placed in cases, in which there is a lid containing calcium chloride.

Development.—The surface of the print should be placed for at least four seconds in a solution composed of 130 grains of potassium oxalate to 1 ounce of water. The development will be instant and complete.

The print should then be washed for ten minutes in a solution composed of 10 parts of citric acid to 100 parts of water. Another, and perhaps better, solution is 1 part of hydrochloric acid to 60 parts of water.

The prints should be finally washed in copious relays of clean water for at least fifteen minutes.

Further Details of Procedure.

The Opacity of the Lines of the Delineation.—In the preparation of the tracing intended for heliographic reproduction, the first essential is the character of the lines of the figure, which should be of a high degree of opacity. The best liquid Indian ink should be employed, if prepared from the solid. Great care should be taken to make it sufficiently dense. Grey lines of imperfect opacity only give very imperfectly defined copies. The

opacity of the Indian ink can be increased by the addition of gamboge or chrome yellow, and the addition of raw sienna is highly recommended. A specially opaque Indian ink is sold by engineering stationers.

Shading.—Shading can be effected either by Indian-ink lines of varying breadth and distance, or by employing ink of variable opacity. The method employed in the author's drawing-office, and introduced by Mr. Vickers, is to shade with crayon and stump, by which most effective and pleasing results may be obtained. Lead-pencil shading may also be adopted, but not with such effective results as with the stump.

Colouring Negative Heliographs.—If variable coloured heliographs (white-figures on blue-ground) are desired, this can be effected, but with only partial success, and by employing a colour of high opacity for the tracing. This colour should be mixed with flake or Chinese white added in the necessary proportions to secure opacity. Instead of dead colouring, hatching in the different colours with the brush is very effective.

The coloured surfaces will be reproduced in more or less white tones on the heliograph, and on these surfaces the different colours, rendered opaque as described, can be applied.

Centre and Radial Lines.—Centre, radial, and dimension lines particularly for the ferro-prussiate process, are first drawn on the tracing with dotted Indian ink, or, if in full lines, with prussian blue, carmine, or raw sienna, to which is added a small portion of flake or Chinese white.

Characteristic Hatching.—A system employed on the Continent in use for negatives, or white-lines on blue-ground copies, as a substitute for structural materials classification, is the employment of characteristic hatching. The author has drawn up a suggested structural element classification code, shown in Fig. 12 (Plate III.). To avoid confusion, when employing characteristic hatching, a key or reference-table should be supplied.

Shrinkage of Heliograph and Tracing-paper.—In order to enable the exact shrinkage of important and complicated drawings, in which high delineative and scale-accuracy is important, it is advisable to draw on the tracing to be copied a scale in two directions at right angles to each other, and in exceptional instances in a diagonal direction as well. The shrinkage-scales will be reproduced in the heliograph copy, and will form an index of the shrinkage-action of the heliographic paper.

The shrinkage-degree depends, of course, on the texture of the paper, the denser and harder this is the less the shrinkage, while soft papers are subject to a much greater degree of shrinkage. The shrinkage of ferro-cyanide, ferro-prussiate, and Pellet papers is about 0·005.

Effecting Erasions and Additions to Cyanotype Heliographs.—For the ferro-prussiate copies, corrections and additions may be effected with a diluted solution of oxalic acid, or a solution of carbonate of potassium in the proportion of 1 part to 9 parts of water. Flake or Chinese-white colour may also be used.

For the Pellet process, a solution composed of 1 part of caustic potash to 28 parts of water is most effective for making alterations and erasures. The solution should be applied either with a quill pen or brush and be immediately blotted, to prevent the action from spreading. Oxalic acid may also be employed in the same proportion as the caustic potash.

A solution sold by heliographic stationers under the name of blue-solving enables additions to be made to heliographs produced by the Pellet process and in the same blue tint.

For the ferro-gallic process, a solution composed of 1 part of sulphuric acid to 99 parts of water, will enable erasures to be cleanly and neatly made.

Preparing the Heliographs for the Workshop.—When the ferro-cyanide or ferro-gallic heliographs are intended for the workshop they should be coated with hard white varnish. This will prevent the chemical character of the print from being damaged by stains from lubricating-oil, etc. For the rougher classes of work the prints should be mounted on linen, using fresh white paste (free from acid or alum) applied evenly to the back of the heliograph.

Excellent gummed paper on cotton for mounting heliographs, etc., can be obtained. The gummed surface should be damped with a sponge or soft brush, and the heliograph laid on and smoothed down from the centre with a soft cloth.

Excellent linen-mounted sensitized papers can now be obtained at such a price as to make their application more economic than the system of mounting ordinary-paper heliograph prints.

Tracing-Paper.—A good tracing-paper should possess the following qualifications. It should be extremely tough and be perfectly transparent. Alkaline papers are the best. It should not cockle or stretch with wash colour, nor deteriorate, either in translucency or toughness, with age. Tracing-cloth is an excellent medium for obtaining satisfactory heliographic prints.

APPENDIX A.—Sensitizing Solutions Applied to Paper.

(1) *Ferro-prussiate Process.*

The solution applied to the paper should be composed as follows :— Ferric ammonic-citrate, 140 grains ; potassic ferri-cyanide, 120 grains ; distilled water, 2 ounces. The solution should be kept in stoneware bottles, $9\frac{3}{8}$ ounces of ferric ammonic-citrate and $6\frac{1}{4}$ ounces of potassic ferri-cyanide being dissolved separately in pure water, and then made up to one quart of solution. The sensitizing solution should be applied to cream-laid paper, rolled and well sized by a flat damping-brush, 6 inches wide, or a tuft of cotton-waste, and the paper should be allowed to dry in the dark. The solution should be applied uniformly and just sufficiently to cover the paper. After drying in the dark the paper should be rolled and stored in special cases.

Theory of the Process.—The results are due to the influence of actinicism, as a reducing agent, on organic ferric salts, which are reduced to a ferrous state. Prussian blue is formed by the reaction of ferric compounds with potassic ferro-cyanide, while white ferrous compounds form a white soluble salt with the same liquid.

(2) *Ferro-cyanide or Pellet Process.*

The sensitizing solution is composed of the following constituents :— Sodium chloride, 3 parts; ferric chloride, 8 parts ; hydrogen tartrate, 4 parts ; water, 100 parts.

The solution is thickened by the addition of 25 parts of gum arabic. In order to prevent the solution from sinking into the paper it should be applied as rapidly as possible. The theory is the same as that of the ferro-prussiate process.

(3) *Ferro-gallic or Shawcross Process.*

The sensitizing solution consists of :—Gelatine, 150 parts ; ferric sulphate, 60 parts ; sodium chloride, 94 parts ; hydrogen tartrate, 18·8 parts ; ferric chloride, 150 parts ; water, 110 parts.

The solution should be uniformly spread over the surface of unsized or specially treated paper, by means of a roller-pad, and the paper dried in the dark. It should then be dusted over with finely powdered gallic or tannic acid. The powder should then be thoroughly rubbed on to the paper, until it is brought into contact with every part of the sensitive surface, four coatings being applied. Some makers, in order to prevent

the sensitizing solution from approaching the size of the paper, pass the paper, before being sensitized, through very hot rollers, to harden the surface and prevent the sensitive solution from sinking into it.

Theory of the Process.—A ferric-gallate is formed by the combination of gallic acid with a ferric salt; this ferric salt, by the influence of actinicism, is reduced to the ferrous state.

(4) *Platinotype (Willis) Process.*

This process is patented, and the details of the sensitizing solutions are therefore not published. The theory of the process is based on the reducing action of a ferrous salt on metallic chlorides when exposed to actinic light.

APPENDIX B.—Specification of Heliographic Equipments.

(1) *White-lines on Blue-ground (Ferro-prussiate) Process.*

One printing-frame, either hung on standards on the Thwaite principle, or merely portable. The glass to be 41 inches by 28 inches, and $\frac{1}{4}$ inch plate, free from all blemishes. There should be a suitable size of felt pad.

The Thwaite vertical, or other ordinary horizontal or tray-bath should be lined with zinc and fitted with the necessary handles; and it should be of the dimensions suitable for developing the largest sized sheets that can be dealt with by the printing-frame. Cost about £5 10s.

(2) *Blue-lines on White-ground (Ferro-cyanide or Pellet) Process.*

Printing-frame and developing-bath as above.

One guttapercha-lined tray-bath of suitable dimensions.

One zinc-lined tray-bath, with handles, of suitable dimensions. Cost about £6 10s.

(3) *Black-lines on White-ground (Ferro-Gallic) Process.*

Printing-frame and developing-bath as above.

One lead-lined tray-bath and one zinc-lined tray-bath of suitable dimensions, and fitted with suitable handles. Cost about £8 10s.

The following gentlemen and firms, viz., Messrs. Bemrose & Sons, Limited, Derby; Eastman's Photographic Materials Co., Limited, London; Mr. J. R. Gotz, London; Mr. Richard Keene, Derby; Messrs. Marion & Co., London; Mr. Parry, C.E., Liverpool; Messrs. Smith & Co.,

Manchester; Mr. W. F. Stanley, London; and Messrs. Thwaite, Tozer, & Co., Limited, London; exhibited examples of heliography by the ferro-cyanide, the ferro-prussiate, the ferro-gallic, the platinotype, and the baryte processes. A fine and interesting collection of every-day examples of heliography, as carried on under the supervision of Mr. Shawcross, C.E., of the waterworks engineer's department of the city of Liverpool, were exhibited. This collection lent by Mr. Parry, waterworks engineer, Liverpool, proved the permanency of ferro-cyanide and ferro-prussiate prints, a qualification further proved by drawings from the late Count de Lessep's ateliers, and by other French and Spanish examples nearly twenty years old. Some of the tracings and heliographs exhibited were prepared by Mr. Shawcross seven years ago; and both tracings and heliographs were in an excellent state of preservation. A comparison of the tracings with the heliographs, some of which showed patches, proved the readiness with which erasures could be made, and imperfections could be remedied. A very large heliograph cartoon (180 inches long by 30 inches wide) showing the dam of the Vyrny waterworks, illustrated how a very large scale drawing can be made by first preparing the details to one large scale (none of the drawings being larger than double-elephant or drawing-board size), then taking multiple copies and combining them up into a compact whole. The heliograph cartoon showed a long elevation to a large scale made up in this way in a most rapid and convenient manner, the only parts drawn in by hand being the varying rock-surface of the ground. The mounted heliographs shown appeared to be permanent and as effective as ordinary drawings. Other copies illustrated the original experiments made by Mr. Shawcross in converting the Pellet or ferro-cyanide (blue-line) process, into darker blue or black-lines. Other interesting exhibits showed the development of the ferro-gallic (black-lines on white-ground) process, of which Mr. Shawcross was the original inventor; the high state of perfection of this process was shown by numerous examples from well-known firms. Examples of a black-line on white-ground process, with merely a water-developer, were shown by several of the exhibtors, together with a series of platinotype prints by Mr. Richard Keene, of Derby. Examples of suitable tracing papers, printing frames, and other requirements of a heliographic equipment were exhibited. Eastman's Photographic Materials Co., Limited, exhibited examples of baryte paper. The methods of shading, colouring, and characteristic methods of colouring constructional drawings that have to be heliographed were shown by several exhibits prepared by Mr. Vickers of Messrs. Thwaite, Tozer, & Co., Limited.

This exhibition was the first of its kind, and should tend to the popularization of engineering heliography as an aid to engineering construction.

The PRESIDENT moved that a vote of thanks be given to Mr. Thwaite for his valuable paper.

The meeting was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
APRIL 27TH, 1895.

MR. JOHN DAGLISH, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on March 30th and that day.

The proceedings of the Council of The Federated Institution of Mining Engineers were reported.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. GILBERT LITTLE, Manager, Engineering Works, 3 and 4, Lime Street Square, London.

Mr. WARDLE STEEL, Manager, Willington Colliery, County Durham.

Mr. W. DUNCAN WILLIAMSON, Chemist and Metallurgist, Mexican Gold and Silver Recovery Co., Ltd., 2A, Calle de la Providencia No. 7, Mexico, D.F.

ASSOCIATE MEMBERS—

Mr. CHARLES EDWARD HUNTER, Coal Owner, Selaby Park, Darlington.

Mr. A. LARSEN, Explosives Agent, The Carbonite Syndicate, Ltd., 24, Queen Victoria Street, London, E.C.

Mr. JOHN MARSHALL, 108, Poolstock Lane, Wigan.

ASSOCIATES—

Mr. JOHN NAISBITT, Overman, No. 48, Tudhoe Colliery, Spennymoor.

Mr. JOHN RAMSAY, Under Manager, Tursdale Colliery, Ferryhill.

STUDENTS—

Mr. HERBERT CHAPMAN, Mining Student, Hebburn Colliery, Newcastle-upon-Tyne.

Mr. NORMAN THORNTON, Mining Student, Pelton Fell, Chester-le-Street.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

The SECRETARY read the "Supplement containing the Results of Experiments with Westfalit, and a Further Series of Experiments with Detonators."

Mr. M. WALTON BROWN stated that the Council had considered the following question, which Mr. John Wilson, M.P., had asked in the House of Commons, and Mr. Asquith's answer, and had decided to offer to the Secretary of State for the Home Department the use of plant erected by the Institute for testing explosives to be used in mines :—

Mr. John Wilson (Durham) asked the Secretary of State for the Home Department whether he has decided to utilize the apparatus for testing Westfalit, erected at Messrs. Pearson & Knowles' collieries, near Wigan, for testing all other safety explosives used in mines, and whether he is aware that efficient apparatus has been erected by the North of England Institute of Mining and Mechanical Engineers, at a cost of about £500, and which has been seen and approved by several members of the Royal Commission on Explosions from Coal-dust, and, if so, whether he will take steps to secure that any experiments with explosives now used in mines shall be carried out by gentlemen not connected with the manufacture of explosives.

Mr. Asquith said he had not decided to cause this apparatus to be utilized, but if there should be need of it he would be very willing to accept the loan of suitable apparatus from any quarter. He was aware of the apparatus belonging to the North of England Institute of Mining and Mechanical Engineers; in fact some of the inspectors of coal-mines had been assisting at their experiments. Until the passing of a Bill dealing with the use of explosives in dangerous mines it would be premature to initiate experiments with different sorts of explosives, but he was fully alive to the necessity of impartiality in any experiments that might be made, and he might add that he hoped very shortly to introduce a Bill.

Mr. JOHN HOUSE wrote that from the fact that so many and careful experiments had been made in various mixtures of fire-damp and air, in addition to those with coal-gas and air, he regarded the experiments conducted by the Institute as unique, and as the most valuable of any which have been made in Great Britain, from every point of view, with the exception, perhaps, of the weights of explosive used for each charge, which he thought should have been more nearly those used in actual underground work, namely, from two to twelve times the weights adopted by the Explosives Committee. These weights seem, at first sight, to show a greater variation in the weights per shot of explosive

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593.

used than practice itself would authorize. To prove, however, that there was this great latitude, and that the maximum charge which he had mentioned was actually employed in blasting in coal-mines, he would submit a few figures to show the weights of explosive used per shot for varying circumstances in the mines under his charge. In a coal-seam 2 feet thick, and in which the coal is strong, the weight of roburite used in each shot varies from 2 to 3 ounces; in a coal-seam 3 feet 9 inches thick, but of only a moderately strong nature, charges of $3\frac{1}{2}$ and 4 ounces are ordinarily employed; in another coal-seam of 4 feet average thickness, but of a strong character, charges of 4, $4\frac{1}{2}$, or 5 ounces, and occasionally of 6 ounces are used, according as circumstances of "end," "face," or "fast" sides determine. In roofing-down stone canches, the charges vary from 4 and 6 ounces of roburite in ordinary shales to 10, 12, and 14 ounces in strong metals; and in rock-roofs 12 and 16 ounces are the regularly allotted charges. He was of opinion that if those officials and workmen, who are so tenaciously prejudiced against any and all substances proposed to be introduced as substitutes for blasting-powder, are to be educated to the knowledge of the dangerous character of their favourite blasting agent, and converted to the views of those who desire to select the safest substitute extant, it is of the greatest possible importance that experiments should be conducted with weights more nearly resembling those actually adopted in underground blasting operations. As there is some possibility of the various explosives being judged from tests made in the experimental apparatus for ascertaining their relative safeties when fired in gas and air; coal-dust and air; and gas, coal-dust, and air mixtures, he desired to draw attention to the absolute necessity of fixing upon a series of conditions which would embrace all the points which practical mining engineers should require from any explosive before selecting it as worthy of confidence, or if none are deserving of complete confidence, before saying which explosive forms the nearest approach to the ideal. Whatever discussion may arise thereon, he (Mr. House) hoped that the outcome might be the framing in a clear and decisive manner of a series of conditions for fulfilment by safety explosives, or those claiming to be such, that a colliery manager may, by their aid, experience the least possible difficulty in pronouncing a verdict upon the merits of such explosives when the results of the necessary experiments are placed before him. He (Mr. House) thought that the essential conditions were as follows:—(1) The explosive shall be incapable of being fired except by means of purposely constructed detonators. (2) It shall be of such a character that it cannot easily take fire, and cannot

burn in the hole, in case of partial detonation. (3) It shall not be liable to become frozen. (4) It shall not be liable to exude a dangerous liquid. (5) It shall be capable of being manufactured of uniform quality and composition. (6) When used in the regular way with stemming or tamping, it shall be incapable of firing explosive mixtures of fire-damp and air, or coal-dust and air, or both combined, even under conditions of a blown-out shot. (7) The products of combustion shall be completely gaseous. (8) The fumes, or products of combustion, shall be neither poisonous nor inflammable. (9) The element of safety in the explosive shall be self-contained. (10) The explosive shall be an efficient blasting agent for use in either coal or stone. The reasons for the particular conditions which he (Mr. House) had here laid down, dealing with them in the order in which they appear above, were as follows:—(1) Accidents, many of them trifling, but some of them serious and grave, and often attended with loss of life, have been occasioned by explosives being of an inflammable character, so as to be easily ignited by means of even a spark, or by concussion such as would be occasioned by letting the explosive fall, or by a blow or shock; or by the explosive being liable to spontaneous decomposition; or being dangerously sensitive to rises in temperature. He was of opinion that the safest explosive, so far as the circumstances here enumerated are concerned, is that which could only be fired by means of a purposely constructed detonator. (2) This condition, which demands that no explosive shall be liable to take fire and burn in the hole in case of partial detonation, is one which, to all practical minds, needs no comment. Tonite was at one time used to some extent at several collieries in Lancashire, but the experience of those who have tried it is that on many occasions, when partial detonation only has taken place, the part not completely detonated has merely been set on fire, and has fizzed in the hole, until the stemming has yielded, and part of the burning cartridge has been projected from the hole, rocket fashion, in a blazing condition. This constitutes a dangerous feature not for a moment to be tolerated. Of course, if it be agreed that the first condition is valid, then the second condition is also included; but if the first condition is not considered to be important, the second condition then becomes an urgent necessity. He believed that other explosives, namely, those which are liable to freeze, might in a semi-thawed condition be liable to this mischance, and he understood that such occurrences had taken place. (3) One danger from freezing had already been mentioned; another danger arose from the possibility of the ill-informed, or careless operator, endeavouring to force a detonator into a frozen or partially thawed cartridge. The greatest

danger, however, was incurred in thawing the frozen explosive. He need not refer to the proper method of thawing frozen cartridges, or to the rude and hazardous expedients which have been resorted to for this purpose, and which have often ended in disaster. (4) Nitro-glycerine compounds all exude nitro-glycerine to a greater or less extent. And every element of safety disappears with the exudation of nitro-glycerine from the cartridge. (5) The inconvenience, which at times has been occasioned by one consignment of an explosive differing in composition and in quality from a former consignment of the same explosive, renders it absolutely essential that a safety explosive shall be capable of being manufactured of uniform quality and composition. Some of the ingredients used in the manufacture of explosives offer greater obstacles to uniform manufacture than others, with the result that sometimes one supply of explosive may be, as regards blasting efficiency, all that can be desired; and another supply may obstinately refuse to detonate, and is compressed into a hard, solid substance in the hole. This defect only appears in the Sprengel explosives. Should any other class of explosive be incompletely detonated, the strong liability is for it to merely burn in the hole as already mentioned. (6) Many have been, and many are, the claimants for the position of a safe substitute for gunpowder; and up to the time of the issuing of the Explosives Committee's unbiassed *Report*, many have been the doubts, and many have been the fallacies held with respect to the merits of the rival explosives. (7) It is alleged that the solid products of the combustion of gunpowder, dynamite, etc., in a finely divided state, when projected at a high temperature into the atmosphere of a mine, may ignite dangerous mixtures of air and fire-damp or coal-dust. If this statement be true, it immediately becomes essential that "the products of combustion shall be completely gaseous." (8) The condition that "the fumes, or products of combustion, shall be neither poisonous nor inflammable," will commend itself to all. Carbon monoxide is an exceedingly injurious gas, 1 per cent. being fatal to life, and smaller percentages cause great injury to the health when frequently inhaled; consequently explosives, which on perfect detonation produce this gas, should not be commended for use. Profs. H. B. Dixon and Vivian B. Lewes state that, when this gas is present in a slight proportion in the atmosphere of a mine, coal-dust explosions may easily be produced by a blown-out shot. Explosives which form nitric fumes should also be avoided, as this gas is also capable of causing considerable injury to health. Hydrogen and fire-damp should not be found amongst the products of combustion of an explosive. Sprengel explosives do

not, on complete detonation, produce inflammable gases, and in this respect seem to possess a great advantage over other classes of explosives. If some independent chemist would make analyses of the products of combustion of the various explosives, he would confer a great boon upon colliery managers who are engaged in the task of discovering the properties of the various explosives now on the market. (9) It is essential that "the element of safety in the explosive shall be self-contained," that is, the explosive shall not rely upon extraneous assistance for lowering the initial temperature of its ignition, such as special stemming-material or water-cartridges as used with several explosives. These outside safety appliances may not be used, or may fail when used at some crucial moment. (10) It is also essential that "the explosive shall be an efficient blasting agent for use in either coal or stone." An explosive possessing the meritorious qualification of safety in explosive atmospheres is of no value if, when introduced for practical blasting, it does not furnish efficient results. The foregoing remarks have been made with the intention of showing other directions in which the Explosives Committee might with advantage make further experiments. The experiments made at Hebburn colliery, apart from strict impartiality (which is not their least recommendation), possess intrinsic value of the highest order, firstly, by reason of the efficiency of the apparatus employed; and, secondly, because the various explosives have been tested in true fire-damp and air mixtures. He (Mr. House) had briefly summarized the important results of this series of experiments as follows:—That all the explosives (ammonite, ardeer powder, bellite, carbonite, roburite, and securite) produce flame in a naked or unstemmed state, when no gas is present, and also in presence of inflammable mixtures of both coal-gas and air, and pit-gas and air. That this flame in the case of every unstemmed explosive is capable of igniting inflammable mixtures of coal-gas and air, but that in similar mixtures of pit-gas and air, the flames of unstemmed bellite, carbonite, and roburite have not caused ignition in twenty-five trials, whereas in the same pit-gas and air mixtures the flames of unstemmed ammonite (first shot), ardeer powder (fourth shot), and securite (first shot) have produced ignition. That when stemmed with 1 to 8 inches of damp puddled clay rolled into cylinders, all these explosives are capable of igniting inflammable mixtures of coal-gas and air, but that in no single instance did any of them ignite inflammable mixtures of pit-gas and air. These results have certainly taken mining engineers by surprise, and some of them seem difficult to account for. Previous to the issue of the *Report*, he (Mr. House) was of

opinion, and many others, held similar views, that all explosives when unstemmed would fire inflammable mixtures of coal-gas and air, and he certainly held the conviction that all explosives when unstemmed would also fire inflammable mixtures of pit-gas and air (although he had had no facilities for proof in the case of the pit-gas and air mixtures. He was surprised to find that the flames of unstemmed bellite, carbonite, and roburite had not ignited inflammable mixtures of pit-gas and air in twenty-five successive experiments. If this excellent record be maintained by future experiments, these three explosives must necessarily occupy the front rank. His next surprise was furnished by the experiments with stemmed explosives. From experiments that he had conducted in inflammable mixtures of coal-gas and air, he was of opinion that at any rate the Sprengel explosives were safe with about 4 inches of stemming for a 4 ounces charge, and that the addition of 1 inch of stemming for every extra 1 ounce of explosive would safeguard heavier charges, and he certainly expected that similar results would occur in inflammable atmospheres of air and fire-damp. The seventh conclusion of the *Report*, viz.: "The emission of flame from a blown-out shot of a detonated high explosive is not prevented by the quantity or length of stemming used,"* seemed to be justified by the experiments made by the committee. Now, although he did not desire the slightest relaxation of the General Rules (in the Mines Act) with respect to explosives, and although he would strongly deprecate the use of an absolutely perfect explosive (if ever there should be such a thing) in the presence of fire-damp in mines, yet he must maintain that stemming as used in actual practice must give a high degree of safety against the emission of flame, even should a blown-out shot occur. Though firing several hundred shots a week with a high explosive (roburite) in the mines under his charge, he had only had two cases of blown-out shots in five years. This fact proved the greatly lessened chances of blown-out shots with high explosives, and the results of the two cases mentioned tend to prove the value of stemming in actual blasting work, even should the shot be blown-out. The first blown-out shot (above referred to) was ignited by the fireman with the electric exploder in the usual way, no flame was seen, and no trouble, inconvenience, or mischief followed. The second blown-out shot (above referred to) happened in a different way. The collier, according to his own admission, which all the circumstances of the place after the event tended to corroborate, was engaged in unramming a missed shot in which the wires of the electric detonator had

* Page 41.

been short-circuited, and had not exploded. The charge was 6 ounces of roburite, and when the shot had been unrammed to within about 8 inches from the charge, he tried to pull the detonator out of the hole by force. The detonator was thus crushed by being drawn violently into the compact stemming, and the charge exploded. The stemming was blown out and struck the collier in the hands and breast, his eyes, fortunately, not being affected. The man stated that he saw no flame at all, and the hot products of combustion and stemming-material, although they turned his skin a red colour, and caused a burning sensation, had in no way scorched him. His skin was also pitted all over with pellets from the ramming or stemming. The man recovered in a short time from the effects of the shot upon his breast, the most serious injury being the shattering of the little finger of the hand nearest the explosive when it exploded. He was of opinion, with respect to the inefficiency of the stemming found in the committee's experiments, that it was due to the smoothness of the bore of the cannon which (having been obtained by the drilling-machine and being in steel) afforded no comparison with the rough sides of a shot-hole made in coal or stone, the roughness affording a certain degree of grip to the stemming, even should it be blown-out. The result of the resistance so afforded would be to allow time for the absorption of some portion of the initial heat by the combustion-products, by the stemming and the sides of the borehole, thus assisting the reduction of the heat generated to a point below that of the ignition of gas and air. In the smooth bore of the cannon the stemming is but loosely placed, for fear of damage to the cannon should the resistance be too severe, and the stemming is hurled out of the cannon with as little resistance as a projectile from an ordinary gun. These circumstances operate to the disadvantage of all the explosives tested under conditions of stemming. He was of opinion that if the experiments with stemmed shots could be made under circumstances more analogous to those of the mine, different results would be obtained from those recorded by the committee, and that several of the explosives under consideration would be found suitable for use in inflammable atmospheres of either coal-gas or fire-damp. Of course experiments with this object cannot be undertaken in the mine, but he suggested that to obtain almost identical conditions with those of the mine, experiments should be made in a short stone-drift or tunnel driven into the rocks of a hillside, quarry, or even a natural cave, if a suitable one could be found. This might entail some expense, but the Government might be induced to contribute to, or even defray the whole costs of such experiments,

considering the mighty issues at stake. Should experiments be conducted in such a stone-drift, or tunnel, or cave, the great advantage would be that in lieu of the cannon, the shots would be fired in holes in the actual stone measures. In this case stemming would be employed as it is in mining operations, and if an occasional shot did not become blown-out as arranged for, but forced down the rock instead, the only trouble that would be occasioned would be the mere drilling of a fresh shot-hole. With regard to the greater degree of safety which the committee's experiments have proved shot-firing in fire-damp and air to possess over similar shot-firing in coal-gas and air, he might say that he was prepared in the abstract for such a result, but he was not prepared to find that any explosive could safely be fired unstemmed in inflammable mixtures of fire-damp and air, any more than he was prepared to find that any unstemmed explosive could be fired in explosive atmospheres of coal-gas and air. He had read with great interest the discussion upon this particular matter by some of the members. His opinion was that the phenomenon is not to be explained by the small difference of 34 degs. Fahr. in the ignition-points of the respective gases when mixed with air, but by the longer time during which it was necessary to apply heat to secure the ignition of fire-damp and air, as compared with the time taken for the same heat to ignite coal-gas and air. The retardation of ignition was, he believed, due to the sluggish nature of the fire-damp, partly owing to the presence of other combinations than marsh-gas in the fire-damp, and partly attributable to the character of the marsh-gas. If this greater degree of safety was due to nothing more than such a difference of 34 degs. Fahr., he agreed with Mr. Henry Hall that it would be but a slender thread to depend upon for safety, and one which might in some cases disappear altogether, and everyone would strongly condemn any disposition to take advantage of such a circumstance in underground work. His (Mr. House's) remarks were intended chiefly to show:—(1) That there is a danger of an explosive being valued according to its behaviour in the experimental apparatus for testing its safety in inflammable atmospheres, without reference to other conditions which the exigencies of mining demand. (2) Although admitting the supreme importance of the abilities of an explosive to withstand these safety-tests in inflammable mixtures of gas, coal-dust, and air, yet it is decidedly advisable that a complete series of conditions be framed to cover all liabilities to accident from every possible cause, and also to cover the requirements of actual blasting; and that explosives be considered as to their competency to comply with the whole

of these conditions. (3) That stemming as applied in practical mine-blasting is not comparable with that employed in the experimental cannon, and that the stemming in the former case yields, under the conditions of blown-out shots, greater efficiency in assisting the lowering of the initial temperature of ignition of the high explosives, enumerated in the *Report*, below that necessary to ignite inflammable atmospheres. (4) The necessity of experiments to thoroughly test the efficiency of stemming, in cases of blown-out shots in inflammable mixtures, under conditions strictly comparable with those of mining. In conclusion, it is evident that the explosives experimented upon by the committee form most valuable substitutes for the old fashioned blasting-powder, and although no single one of them is absolutely safe under all conditions, yet they are all safer to use than gunpowder, in the presence of inflammable mixtures; and although some of them seem to possess higher merits than others, yet any one of them, as regards safety, is infinitely to be preferred to gunpowder, which has caused such calamities in the past.

Mr. Harold Bonser (Leeds) said that some objection might be made as to the tests made by the committee with regard to the detonators used; it would only have been fair in testing ardeer powder to have used treble detonators, as recommended by the manufacturers. He was of opinion that whatever quantity of ardeer powder was used, the length of the flame was the same, the flame being due to the detonator and not to the explosive. The relative weights of the explosives used in the experiments, as determined by the results of the experiment in leaden blocks, would not commend itself to practical men in actual working; thus $3\frac{3}{4}$ ounces of ardeer powder was certainly stronger than 1 ounce of bellite, one of the results ascertained by the committee. The experiments had been very carefully conducted, and he had no grounds for taking material exception to anything contained in the *Report*. The Royal Commission appointed to enquire into accidents in mines recommended in their final *Report** that high explosives (such as dynamite or gelatine-dynamite), when used in dry and dusty mines, should be surrounded by water, as in water-cartridges, or similar contrivances. During the last ten or twelve years, the water-cartridge placed round an explosive had never been known to fail, and he ventured to suggest that the committee should extend their experiments to the use of water-cartridges.

Mr. W. C. Blackett asked if the conclusions given in the supplementary *Report* were in substitution of the original conclusions published by the committee?

* Page 115.

Mr. J. L. Hedley (H.M. Inspector of Mines) said that the conclusions had been remodelled, so as to render them more clear and concise.

The Chairman said the *Report* stated that although there was only a difference of 34 degs. Fahr. between the temperature of ignition of marsh-gas and oxygen, and coal-gas and oxygen, not one of the seven explosives, when stemmed, had ignited an explosive mixture of marsh-gas and air, whilst, on the other hand, all the seven explosives had readily caused ignitions of explosive mixtures of coal-gas and air.

Mr. R. Laverick (Rainton) said that an incident very recently occurred at one of the pits under his management. A deputy charged a shot-hole with carbonite, and when putting in the second handful of stemming accidentally cut the detonator-wires. He then put in another charge of explosive in front of the first, in the hope that when fired it would explode both charges. After firing, he carefully examined the hole with the view of searching for the first charge, to satisfy himself that it had been exploded. He took all the loose coal, as he thought, from the hole, and concluded that both shots had been exploded. The next morning, however, a hewer who was working in the place struck the charge with his pick and it exploded. The stemming consisted of broken stone, and the length of stemming between the two charges of explosive would probably not be more than 2 inches.

Mr. H. Bonser said in a case of this description it did not necessarily follow, if a shot did not do its work, that it had not been ignited. Recently, two shot-holes were charged with roburite, and the chargeman, as he thought, fired them simultaneously. He detached the cable, removed the magneto-electric exploder, and placed the handle in his pocket. His assistant and another workman then went to examine the place, and to ascertain if the shots had done any work. They halted on the way, about 60 feet from where the shots had been fired; they were about to proceed on their way, when, to their amazement, one of the shots went off, and only two simple circumstances saved their lives—the halt mentioned, and the fact that it was a breaking-down shot.

Mr. Wm. Jas. Orsman (Wigan) said that he was very pleased to be present at the discussion that day, and congratulated the committee on the extreme care and exactness with which the experiments had been carried out. With regard to the further paper that had been read, he could bear out the conclusions of the committee that the incomplete detonation of nitrate-of-ammonium explosives did not render them more capable of igniting inflammable gaseous mixtures. Various weights of

westfalit up to 12 ounces had been fired unstemmed from a strong steel cannon into explosive gaseous mixtures. With No. 6 detonators, containing 1 gramme of fulminate of mercury, incomplete combustion nearly always took place, and no ignition of gas ensued. With Nos. 7 and 8 detonators, containing $1\frac{1}{2}$ and 2 grammes of fulminate, when complete detonation was observed, the explosive mixture was always ignited. In comparing the action of detonators, some distinction should be made with regard to the different makes, which vary considerably in composition. Nobel detonators, which are used principally for explosives containing nitro-glycerine, contain from 25 to 30 per cent. of chlorate of potash, mixed with the fulminate of mercury, whilst ordinary detonators contain only a trace. The large proportion of chlorate of potash contained in Nobel detonators, whilst acting usefully in the case of dynamite, carbonite, and other nitro-glycerine compounds, which are more perfectly decomposed by the action of heat as well as shock, renders them unsuitable for detonating Sprengel explosives, for which intense shock only is required. Consequently, with nitrate-of-ammonium explosives, detonators specially made for them should alone be used. He was of opinion that the use of other detonators was largely responsible for the cases of incomplete combustion which occasionally occurred. In trying the action of detonators themselves in explosive gaseous mixtures, we may expect to find different results with the different makes. A detonator containing chlorate of potash should develop more heat than one containing pure fulminate of mercury, and would give off gases containing heated solid particles of chloride of potassium, which would act like the smoke from gunpowder. The product from pure fulminate of mercury would, on the other hand, be entirely gaseous. Nobel detonators seem to have been exclusively used by the committee in their experiments, and it might be advisable to repeat a few of the experiments with other qualities. With regard to the statement made by Mr. Bonser concerning the hang-fire of a detonator used with a cartridge of roburite, it seemed to have been due to the priming-composition having been faulty and slowly burning away (instead of exploding so as to fire the fulminate instantaneously). A good deal of discussion had taken place with respect to the term "flames" used in the *Report*. There was no doubt that light had been noticed at various points of the apparatus at some distance from the mouth of the cannon. This might be due to (1) incandescent solid matter; (2) incandescent gaseous matter; or (3) reflection. (1) Incandescent solid particles could only be produced by firing those explosives which contain inorganic mineral matter such as gunpowder,

dynamite, gelignite, tonite, etc. With nitrate-of-ammonium compounds, the products being entirely gaseous, no solid particles would be produced from the explosive itself. (2) Incandescent gaseous matter. It has been shown that heavy gases at a high temperature will become luminous, but one can hardly understand that the temperature would be high enough to cause the escaping gases to become luminous. Mr. Saville Shaw had dwelt on the fact that the explosion of gaseous mixtures depended not so much on the temperature as on the time during which the temperature had to be maintained, and he instanced the experiment of burning gun-cotton without igniting gunpowder. In this case the cotton burns so quickly that the sudden rise of temperature fails to ignite the powder. The converse of this experiment shows that gunpowder will always light gun-cotton. If flames were really produced at the distances mentioned, it must mean that burning was taking place all the time the flame lasted, and this would not be a very instantaneous process. In fact this was the first time we have on record the possibility of producing a flame 30 feet long that would not ignite an explosive gaseous mixture. One would imagine that the rush of burning gases along that distance alone would by friction cause ignition. Unfortunately, the results were derived from eye-observations only, and it was a pity that the suggestions in Part I. of the *Report* were not tried, namely, placing tufts of gun-cotton in the path of the flame. As gun-cotton ignited at a very low temperature (below 200 degs. Cent.), and could be ignited by almost instantaneous application of heat, this would have been a most severe test. At the present moment, in the absence of further proof on the above subject, one leant rather to the idea that the light seen was due to reflection. Considering the dusty state of the air which must be produced owing to the disturbances caused by explosion, and by the fan, a ray of light entering from one end ought to be clearly visible at some distance in the otherwise darkened chamber, and the halo of light produced by the detonation of Sprengel explosives might easily be reflected and mistaken for flame. With regard to the other conclusions of the committee (*e.g.*, No. 3) we find that compounds or mixtures containing nitro-glycerine do alter very considerably with age, owing to the exudation of nitro-glycerine, which render the explosive more dangerous, whilst nitrate-of-ammonium mixtures absorb water and so become inert. The statement in clause 7, that increased lengths of stemming did not ensure increased safety, was not borne out by the experience of other experimenters, either when firing from a cannon or in practical work in the mine. An increased amount of stemming meant greater resistance, and consequently a greater amount

of work is done in the coal or stone to be blasted, and the escaping gases must therefore issue into the air at a lower temperature. In a smooth-bore cannon, if wet puddled clay be used, the clay will be ejected in a solid mass, like a bullet, whereas if a stemming of a powdery nature be used, work is done and heat absorbed by breaking up the stemming into fine dust. The amendment of paragraph 8, to the effect that the nitrate-of-ammonium explosives were excluded from the statement that the explosive could be fired by percussion, bears out a paper* presented to the members at an earlier date. It was then shown that mixtures containing nitro-glycerine could be totally detonated by means of a 59 pounds weight dropping on a cartridge from a height of 6 inches and upwards. With the Sprengel explosives, even with a 30 feet drop, no detonation occurred: a small portion only of the explosive being decomposed, owing to the heat evolved by the impact of the iron surfaces. It had been alleged that for various reasons the experiments conducted by the committee were without value. Considering the very small knowledge on the subject, such experiments must be of the greatest possible value, as regards both the exact methods adopted and what may be expected to take place under certain conditions. Such experiments must suggest, and have already started, new lines of thought in students of the subject, and the various points will be taken up and worked out by many experimenters. No explosive ever has and probably none ever will be invented that will be perfectly flameless, but with the Sprengel explosives we have blasting-agents perfectly under control, and relatively safer when compared with gunpowder than a safety-lamp when compared with a naked flame. The fact that, with one at least of the Sprengel explosives, millions of shots have been fired in England during the past eight years without causing an explosion of gas or coal-dust in the mine, places them in the highest position as to safety.

Mr. J. L. Hedley said that Mr. Orsman had raised an important point as to detonators, and this matter had also been referred to by some of the other speakers, who had stated that with the small charge of explosive used the ignition of the gas on several occasions had not been caused by the detonation of the charge but by the detonator, and that the committee were using too small quantities of the explosives. The committee had been using small charges, but these charges were actually being used in mines in this district. He was not prepared to say that the ignition of the gas had not been caused by the detonator, nor was he

* "The Detonation of High Explosives by Percussion." By Mr. W. J. Orsman. *Trans. Fed. Inst.*, vol. iii., page 574.

prepared to say that the detonator had caused the ignition, but if it were admitted that the detonator had caused the ignition of the gas, they were opening up a question which had not been approached hitherto, namely, the use of detonators in mines. It was one of two things. Either the explosive or the detonator ignited the gas. If it were not the explosive, it became a serious matter for consideration as to what was to be done with regard to the detonators. The detonators used in the experiments were obtained in the open market, and supplied to the users of explosives in the different mines of the kingdom. They were now told that if a larger proportion of an explosive were used, the flame from the detonator would be quenched; and another speaker stated that when a still larger proportion of an explosive was used, the flame ignited the mixture. It was possible that a certain weight of explosive might have to be used to kill the flame of the detonator. If that were the case, all the shot-holes must be made of one size and the same weight of explosive used in every case, and this would be going beyond the grounds of possibility. Explosives, when used, had to be used in different weights, and unless explosives perfectly safe under all conditions could be obtained, they could only come to the conclusion that it was not safe to use explosives in mines. Mr. Orsman had told the members that some detonators produced flame and some did not, but was Mr. Orsman prepared to say what kind of detonator should be used, and what mixtures should be used in their manufacture? Mr. Orsman also stated that it was impossible to make a flameless explosive. If that were so, why should the ignition of gaseous mixtures be attributed to the detonator in preference to the explosive? If a detonator was fired in a darkened room, flame could always be seen, and that flame might or might not be able to ignite gas. The experiments with detonators made by the committee showed that in a large number of trials the gas was not ignited, while in a few cases it was ignited: in each case the same kind of detonators was used. Another question raised by Mr. Orsman was with regard to the extra amount of stemming. The committee stated that an extra amount of stemming—from 1 to 8 inches—made no difference so far as the safety of an explosive was concerned, this being the results of the experiments. The stemming used was, as he had previously explained, stiff puddled clay; the pellets were not dropped in, but were rammed in in the usual way.* The clay used was similar in all cases, and the shots were always stemmed under the same conditions; and to ensure this they were all stemmed by the same member of the committee. Mr. Orsman seemed to attach great importance to the friction between the sides of the hole

* *Report*, page 31.

and the stemming, and in the experiments there had always been this friction. The holes had been stemmed in the same way as was now done in a large number of mines—perhaps not coal-mines, but certainly metalliferous mines—in the country. Plastic clay alone was regularly used in a large number of metalliferous mines in this district, and with the very best results. With respect to the detonator hanging fire, he had had two cases under his notice in this district, where it was said the detonator hung fire, and that the shot had gone off afterwards, in one case killing a man and in the other injuring one. If this were so, and Mr. Orsman was of opinion that such a possibility might arise, it only taught them that they would have to be very careful with the detonator, and it pointed to a danger which they had hitherto evidently not suspected and to which they must attach more importance in future, but he did not think it had any bearing on the experiments now under discussion. Mr. Bonser had contended that there was no difference in the amount of flame given off from cartridges of different weights of the same explosive. That might be so in the open air, but it certainly was not the case where shots were fired in the bore of a cannon. The makers of safety explosives stated that they must be confined before they would afford safe detonation. Mr. Bonser had also referred to the use of water-cartridges, which acted efficiently, if they were properly used, but there was always the chance of this not being the case. One of the speakers stated that the flames supposed to have been observed could only be reflections or halos, otherwise the gas would have been ignited; but this matter was fully explained at the last meeting by Mr. Saville Shaw.* That they did get a flame without ignition of the gas was evidenced from the result of the experiments with detonators. If a flame of short duration could be produced by a detonator without igniting the gas, he thought it might be conceded that it was possible also to obtain an elongated flame from an explosive without igniting the mixture. This, however, was a question of opinion, and always would be. The Committee had to trust to their eyesight in regard to the observation of flame. They were told that when small charges of explosive were used they were using too powerful a detonator. He would like to ask the gentleman who made that statement whether the explosives which they had been testing required different detonators for the different weights of explosive used. If so, it was reasonable to infer that with a small charge, they must use a small detonator, and with a heavy charge they must use a very large detonator, and this again raised the question of safety. Of course, if they were to admit that the detonator was

* *Trans. Fed. Inst.*, vol. viii., page 606.

responsible for the ignition, then the larger the detonator the greater the danger, and the only final conclusion would be that the explosive which required the least powerful detonator must be the safest, if it were proved that they were equally safe in themselves. A member had remarked that the experiments were of no value, because the conditions under which they were made were not the same as they were in the mine, but the same speaker admitted that such conditions might exist, though it would not be proper to fire a shot in the mine if it were in that state.* They were all agreed on that point, and if they were all and always to carry out the regulations applying to mines they would not have as many accidents as they had. The explosives had not been tested with the view of showing that any one was better than another, or that any particular one was safe; they only wanted to find out whether, under conditions that might exist in a mine, these explosives were safe or not. The same speaker demurred to a comparison between gunpowder and high explosives with the Trauzl method. The committee did not intend to compare gunpowder with high explosives, and the Trauzl blocks were simply used so as to make a comparison between the different high explosives.

The further discussion was adjourned.

DISCUSSION UPON PROF. STROUD'S PAPER ON "MAGNETIC DECLINATION AND ITS VARIATION,"† AND MR. J. HENDERSON'S PAPER ON "MAGNETIC DECLINATION IN MINES."‡

Mr. A. Beanlands (Durham) wrote that in the course of the discussion a statement had been made, with reference to the Ordnance Survey plans, which required correction. It was assumed that the four sides of each map or sheet corresponded with the true north-and-south and east-and-west directions. This was not precisely true—the north-and-south line passing through the principal station on Brandon Hill, with its continuation north and south, was the only marginal line in this district which coincided with the true meridian. The other north-and-south lines to the east and west of this were only approximate. In the case of the maps drawn to the scale of 6 inches to the mile, each sheet is laid down to contain a rectangular space 6 miles in length from east to west, and 4 miles in breadth from north to south. It was clear that if the line on the east of Durham, *i.e.*, 6 miles east of Brandon Hill, coincided with the true meridian, it must converge

* *Trans. Fed. Inst.*, vol. viii., page 593.

† *Ibid.*, vol. vii., page 268; and vol. ix., page 26. ‡ *Ibid.*, vol. viii., page 273.

towards the north pole, and the upper east-and-west line, must be shorter than the lower east-and-west marginal line, but as the upper, as well as the lower, margin was 6 miles in length, the eastern marginal line must be drawn not truly north and south, but diverging towards the east. Without pretending to extreme accuracy, he made the deviation of this line to be $7\frac{1}{2}$ minutes, or $\frac{1}{8}$ degree ; and 15 minutes, or $\frac{1}{4}$ degree, for the marginal line farther east, *i.e.*, 12 miles from Brandon Hill. In like manner, if we take the Ordnance Survey sheets to the west of Brandon Hill, the marginal lines, 6 miles and 12 miles from the principal station, diverge $\frac{1}{8}$ and $\frac{1}{4}$ degree to the west of the true meridian. Owing to the extreme difficulty of obtaining a loose needle bearing in many cases, as stated by Mr. Henderson, it seemed all the more important, wherever practicable, to obtain a direct connexion between the surface and underground surveys, such as was effected by means of the transit-instrument. He was not acquainted with the kind of shaft commonly met with in Cornwall, but should like to know whether, in case it was impossible to obtain a sight from the surface to the point desired, it would not be possible to set up a theodolite at the point where the inclination of the shaft changed.

Mr. James Henderson (Truro) said that some remarks had been made referring chiefly to the almost absolute impossibility of using the compass-needle with accuracy in underground operations ; he contested this statement because he was satisfied that in most places the needle could be used perfectly, and when applying the compass in a proper way he considered it a most admirable instrument. One gentleman said that he would not think of using a miner's compass for defining boundaries, but it was the only instrument which they did use in Cornwall. In the North of England they could take a line down the shaft from the surface and connect that with the underground survey, but in Cornwall the shafts were so tortuous that it would be impossible to take any line down them from the surface, and therefore they were compelled to trust to the magnetic bearings for intricate work. In mines where inches of ground were important, where lodes were perpendicular, they could imagine what efforts were made by surveyors to attain accuracy, but for the groundwork of all their surveys, whatever instruments they used underground, the best was the miner's compass. The theodolite was a valuable instrument no doubt, and the transit was a still finer instrument, but a transit, or even a fine theodolite, would be quite out of place in the Cornish mines with their small levels only a few feet high. How could they use a fine instrument, with mud and water falling upon it ? In Cornwall they were obliged therefore to revert to the miner's compass ; he would by no means recommend the use of two

instruments—one of first-rate quality at the surface and an inferior one underground. The same instrument should be used in both cases, even though it were of a somewhat inferior kind. Within the last year or two he had introduced what he considered to be a very valuable instrument for the purpose of traversing underground: connecting one's bearings off the traverse by means of a compass-bearing and carrying it on, on the theodolite principle through the mine, and the results of his experiments with the traverser wherever it had been used were most satisfactory, the holing of the shafts being most accurate. He had already had the pleasure of describing the instrument in the *Transactions*.* Mr. Henderson then exhibited and described the instrument referred to.

COAL MINES REGULATION BILL.

The Secretary (Mr. M. Walton Brown) read a paper on the "Coal Mines Regulation Bill."

The Chairman said the subject was one of considerable importance. The propriety of the Institute taking up such a subject had been considered by the Council that day, and it was understood that after the paper had been read the Council would further consider whether it should be published in the *Transactions*.

Mr. W. C. Blackett said it was important that they should have a knowledge of all technical matters which were brought before the Houses of Parliament. The reading of this paper was an innovation, and if it were admitted that this paper came within the province of the Institute, it must be understood that they would have to take cognizance of similar technical measures in future, or otherwise their silence about other bills might be misinterpreted.

Mr. T. E. Forster considered that the matter was not one coming within the province of the Institute.

Mr. J. A. Ramsay considered that the Bill was one affecting mining engineers, and as such should be taken cognizance of by the Institute, inasmuch as recent legislation had practically placed the managers of collieries directly under the control of the inspectors of mines. He thought that any act of parliament which in any way affected the management of mines was a very proper subject of consideration by the members of this Institute.

Mr. J. G. Weeks said the matter was one for discussion by the United Coal Trade and not by the Mining Institute.

Mr. T. E. Forster moved, and Mr. J. A. Ramsay seconded a motion that a vote of thanks be accorded to Mr. M. Walton Brown for his paper.

* *Trans. Fed. Inst.*, vol. v., page 199.

DISCUSSION ON MR. FRANK COULSON'S PAPER ON "SINKING WITH ROCK-DRILLS."*

Mr. H. Bonser (Leeds) wrote that the use of high explosives had been so admirably described by Mr. F. Coulson in his paper, that no further reference is necessary, and all the members could refer to that paper in case any information was desired as to the sinking of shafts by means of high explosives. The economy of adopting the system explained in that paper cannot be too highly emphasized. In the subsequent discussion one of the speakers alluded to the fact that in the Durham district most of the pits required were sunk, and no doubt that was so, but it was equally true that in nearly every colliery it was found necessary to drive stone-heads or drifts or tunnels, and, no doubt, if the members would take Mr. Coulson's paper, and, instead of applying it to a shaft, would apply the self-same method to the tunnel or drift, equally satisfactory results would be obtained. For instance, in a drift progressing at the rate of, perhaps, 30 feet per week, if the holes were lengthened from 4 to 6 feet, and the unkeying-holes (corresponding to the sumping-shots of the shaft) were fired simultaneously, and the side holes were lengthened in the same way, the rate of progress with the same number of men employed would be increased to 45 feet in the same time. The saving would be effected by giving the explosive its full burden of work, and by the time saved in setting and changing drills, delay in firing, etc. The advantage of electric detonating-fuzes over ordinary time-fuzes was not only in igniting the shots simultaneously and the holes or charges, thus assisting each other, but also in the total absence of fumes and smoke from the burning fuzes, which were greatly in excess of the fumes or smoke created by the explosion. Too much emphasis cannot be placed on this point, as the saving in cost of driving a stone-head or tunnel may be from 30 to 50 per cent. of the total. There was just one word of warning to sinkers in wet ground which may require tubbing, that the side or canch holes, if fired simultaneously, may have so disturbing an effect on the strata as to nullify the effect of the tubbing in keeping the water back. In such cases it is better to fire the shots in succession.

The meeting was then closed.

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* *Trans. Fed. Inst.*, vol. viii., page 17.

FIG. 1.

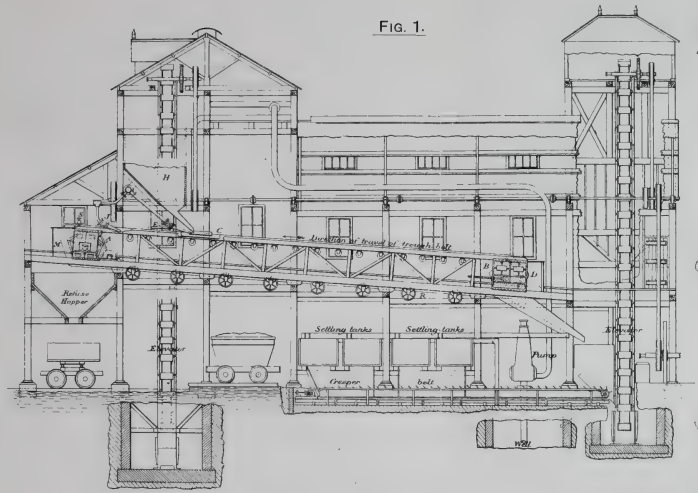


FIG. 5.

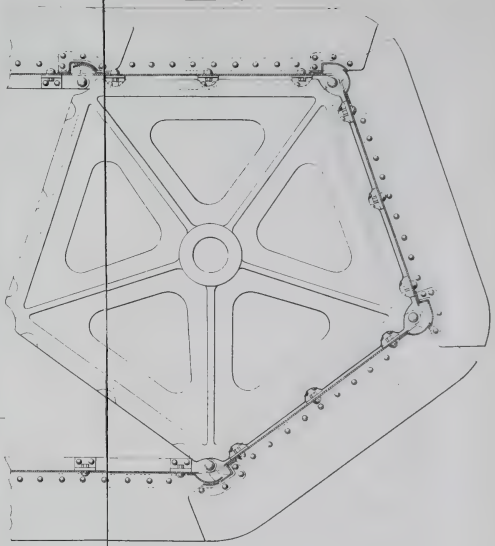


FIG. 2.

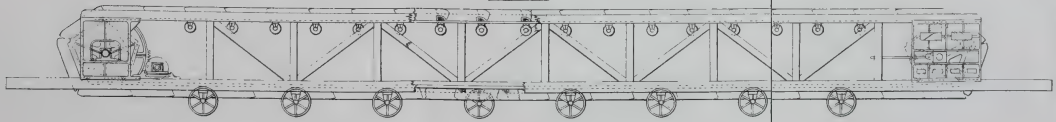


FIG. 4.

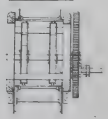
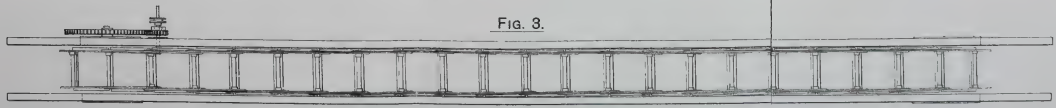


FIG. 3.



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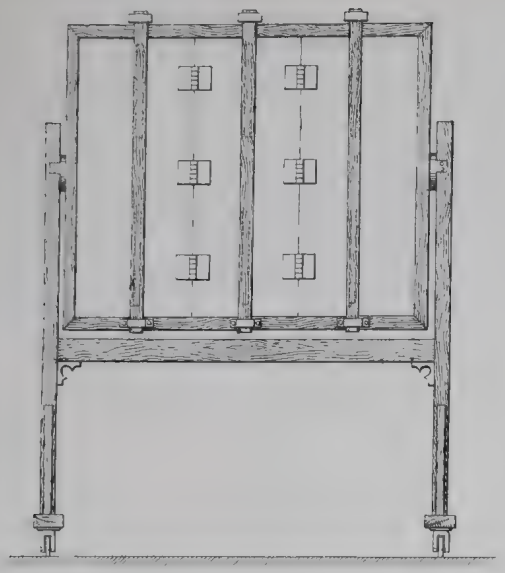


FIG. 1.—BACK ELEVATION.

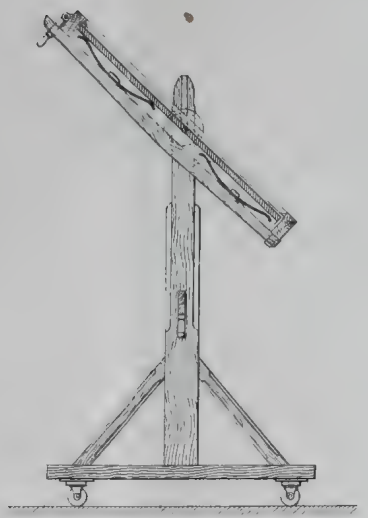


FIG. 2.—SIDE ELEVATION.

FIG. 3.

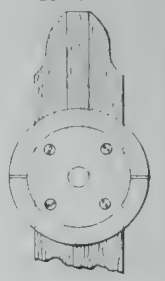


FIG. 4.

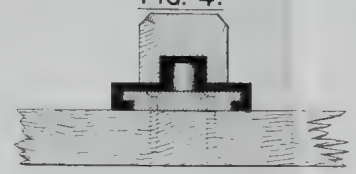
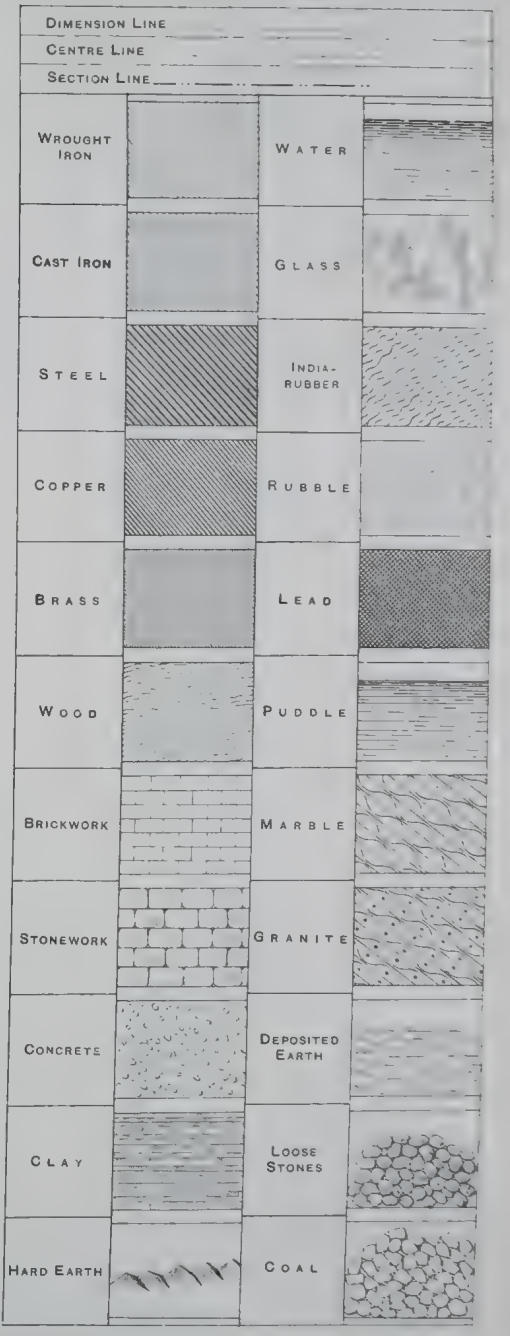


FIG. 12.—CHARACTERISTIC HATCHINGS FOR HELIOGRAPHIC PURPOSES.



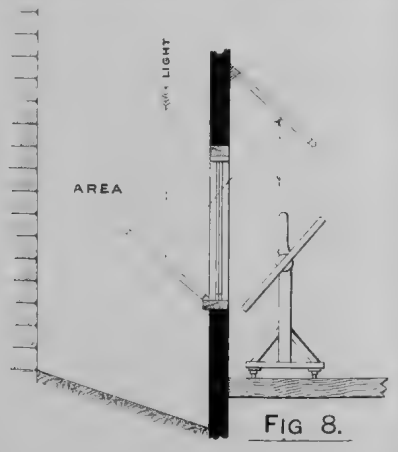


FIG 8.

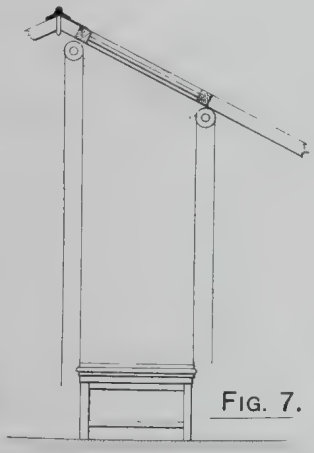
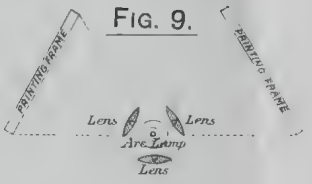


FIG. 7.

FIG. 9.



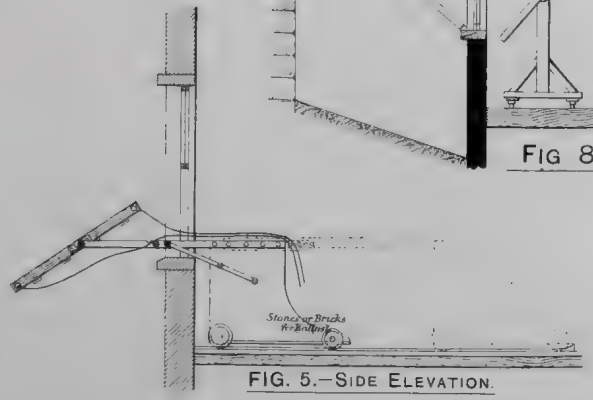


FIG. 5.—SIDE ELEVATION.

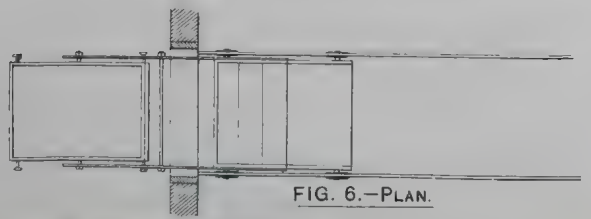


FIG. 6.—PLAN.

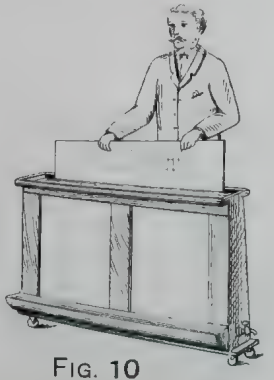


FIG. 10

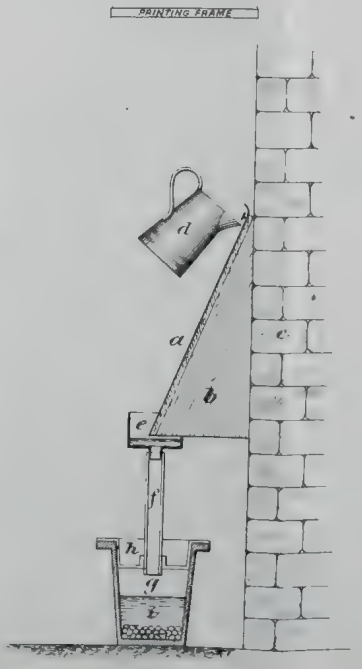


FIG. 11.

To illustrate Mr. B. H. Thwaite's Paper on

"Engineering Heliography," etc.

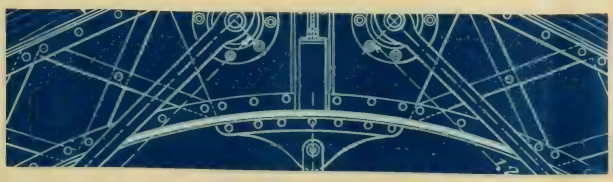


FIG. 13.—White-lines on Blue-ground (Ferro-prussiate) Process.

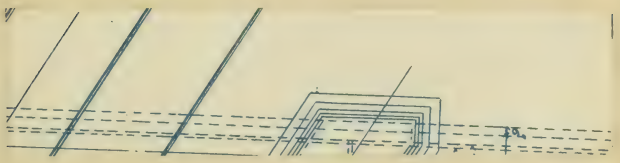


FIG. 14.—Blue-lines on White-ground (Ferro-cyanide or Pellet) Process

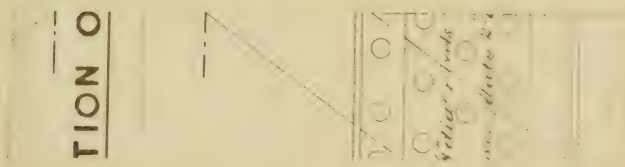


FIG. 15.—Black-lines on White-ground (Ferro-gallic or Shawcross acid-development) Process.

FIG. 16.—Black-lines on White-ground (Ferro-gallic, water-developer) Process

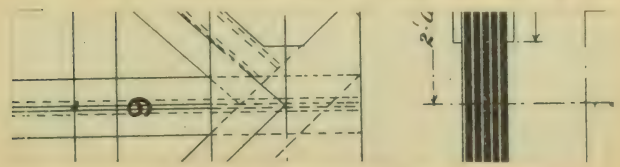


FIG. 17.—Black-lines on White-ground (C.N.) Process.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

JUNE 8TH, 1895.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 25th and that day.

The proceedings of the Council of The Federated Institution of Mining Engineers were reported.

The SECRETARY read the Balloting List, as prepared by the Council, for the election of officers for the year 1895-96.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. DAVID ABRAHAM, Mining Engineer, Pencoedcae, Merthyr Tydvil.

Mr. ENRIQUE ALLCHURCH, Mining Engineer, Buenos Aires, Argentine Republic.

Mr. J. W. BATES, Mining Engineer, Surveyor, Estate Agent, and Valuer, Sutton Hall, St. Helens, Lancashire.

Mr. SIDNEY BATES, Manager, Mickley and Prudhoe Collieries, Mickley Colliery Offices, Stocksfield-upon-Tyne.

Mr. CUTHBERT BURNETT, Engineer, Fallowfield House, South Hetton.

Mr. W. H. CORBOULD, Mining Engineer, The Hannan's Reward Gold-mining Company, Limited, Hannan's Hill, Kalgoorlie, Western Australia.

Mr. FRITZ GILLMAN, Mining and Metallurgical Engineer, Gartenstrasse 1, Freiburg im/B, Baden, Germany.

Mr. JONATHAN HARRISON, Mining Engineer, Kimihia Colliery, Auckland, New Zealand.

Mr. William Pellew Harvey, Mining Engineer and Assayer, Vancouver, British Columbia.
Mr. John B. Hastings, Civil and Mining Engineer, Boise City, Idaho, U.S.A.
Mr. Jacob Hodgson, Mechanical Engineer, Cornsay Colliery, County Durham.
Mr. Carlos A. Lynes Hoskold, Mining Engineer, Buenos Aires, Argentine Republic.
Mr. Kwong Yung Kwang, Mining Engineer, Linsi Colliery, c/o Chinese Engineering and Mining Company, Tientsin, North China.
Mr. W. H. C. Lovely, Mining Engineer, Metallurgist, Assayer, and Mine Surveyor, Coolgardie, Western Australia.
Mr. Francis Herbert Mason, Consulting Metallurgist and Assayer, Arlington Place, Truro, Nova Scotia.
Mr. William Jasper Nicolls, Mining and Civil Engineer, c/o Berwind-White Coal-mining Company, Betz Building, Philadelphia, Pa., U.S.A.
Mr. Thomas George Noble, Manager, Sacriston Colliery, Durham.
Mr. Claud Bowes Palmer, Colliery Agent, Wardley Hall, Newcastle-upon-Tyne.
Mr. John C. F. Randolph, Mining Engineer and Metallurgist, Mill's Buildings, 35, Wall Street, and 15, Broad Street, New York, U.S.A.
Mr. Norman Backhouse Ridley, Engineer, 58, Collingwood Street, Newcastle-upon-Tyne.
Mr. Charles M. Rolker, Mining Engineer, Manager, Mining and Financial Trust Syndicate, Limited, 6, Drapers' Gardens, London, E.C.
Mr. John Smailes, Colliery Manager, Hebburn Colliery, Newcastle-upon-Tyne.
Mr. John Barret Squire, Civil Engineer, 297, Clapham Road, London, S.W.
Mr. John Stanton, Mining Engineer, 11 and 13, William Street, New York, U.S.A.
Mr. William Stewart, Mining Engineer, Tillery Collieries, Abertillery, Monmouthshire.
Mr. Donald M. D. Stuart, Mining and Civil Engineer, Redland, Bristol.
Mr. Francis William Thompson, Civil and Mining Engineer, 15, Wood Street, Bolton, Lancashire.
Mr. John G. Thompson, Assistant Manager, Bamfurlong, Wigan.
Mr. Thomas A. Walker, Engineer and Ironfounder, Pagefield Ironworks, Wigan.
Mr. Henry Wall, Mining Engineer, King Street, Wigan.
Mr. Harry Bartlett White, Mining Engineer and Surveyor, P.O. Box 24, Johannesburg, Transvaal, South African Republic.
Mr. Henry Wilcox, Manager, Miners' Safety Explosive Works, Stanford-le-Hope, Essex.

Associate Members—

Mr. William Henry Franklin, Firth Park Villas, Sheffield.
Mr. John E. Rogerson, Oswald House, Durham.
Mr. Thomas Scowcroft, Tonge Colliery, near Bolton.
Mr. E. Gybbon Spilsbury, Managing Director, Trenton Iron Co., Trenton, New Jersey, U.S.A.
Mr. John Thom, Canal Works, Patricroft, near Manchester.
Mr. Oswald Walmesley, Barrister-at-Law, 2, Stone Buildings, Lincoln's Inn, London.

ASSOCIATES—

Mr. FRANK BOWMAN, Assistant Colliery Engineer, Auckland Park Colliery, near Bishop Auckland.
Mr. ALLAN BROWELL, Under-Manager, Cornsay Colliery, County Durham.
Mr. SAMUEL DUNNETT, Miner, Cambois Colliery, Northumberland.
Mr. H. W. HALBAUM, Stoneman, Boldon Colliery, R.S.O., County Durham.
Mr. JAMES HENRY, Under-Manager, Howgill Staith, Whitehaven,
Mr. WILLIAM ALLEN LOVE, Brickworks Foreman, Cornsay Colliery, County Durham.
Mr. WILLIAM MILLBURN, Surveyor, Cornsay House, Cornsay, Durham.
Mr. GEORGE ROSS PRATT, Under-Manager, Springwell Colliery, Gateshead.
Mr. JOHN ROWE, Under-Manager, Hollinside Terrace, Lanchester.
Mr. GEORGE TURNER, Deputy-Overman, Cornsay Colliery, County Durham.

STUDENTS—

Mr. MATTHEW WILLIAM ARCHER, Mining Student, West Stanley, R.S.O., County Durham.
Mr. WILLIAM MUSGROVE, Mining Student, Throckley Colliery, Newcastle-upon-Tyne.
Mr. JONATHAN SEVERS, Mining Student, Stanley, R.S.O., Newcastle-upon-Tyne.

The following paper on "Experiments with Explosives" by Mr. Winkhaus was read by the Secretary :—

EXPERIMENTS WITH EXPLOSIVES.

By BERGASSESSOR WINKHAUS.*

I.—The Experimental Gallery for Testing the Effect of Explosives on Fire-damp and Coal-dust at Schalke, Westphalia.†

The experimental gallery at the Consolidation pit (No. 1 shaft), near Schalke, was erected by the Westphalian Miners' Provident Society, of Bochum, with funds voted at the general meeting of March 2nd, 1894, and was in working order by the middle of the following August. One of the main reasons for selecting this pit as the *locus* of experiment was that it furnished an abundant source of natural pit-gas, which had for the last ten years been made use of in heating the compressed air, lighting up the shaft-bottom, and other similar purposes. Moreover, the site which was freely placed at the disposal of the experimenters by the owners of the mine was admirably adapted to the object in view.

The plan (Fig. 1, Plate XVI.) shows that the site is an area enclosed on two sides by two old pit-heaps, respectively 23 feet (7 metres) and 40 feet (12 metres) high, and is more than 650 feet (200 metres) distant from the nearest inhabited house. The experimental gallery is built into the north-western slope of the more southerly of the two pit-heaps, and is mostly modelled on a similar structure put up at the Royal König colliery at Neukirchen, in the Saarbrück coal-field.

The experimental gallery (Figs. 2, 3, and 4, Plate XVI.), arranged to accord as nearly as possible with the conditions which obtain underground, is 115 feet (35 metres) long and elliptical in section. Its inside height is 6·07 feet (1·85 metres) and its inside width is 4·43 feet (1·35 metres). The gallery is constructed of strong elliptically bent-frames made of H-iron, which are placed $15\frac{3}{4}$ to $25\frac{1}{2}$ inches (400 to 650 millimetres) apart, and lined with a triple covering of best pitchpine planks of a total thickness of 2·36 inches (60 millimetres). This lining of three layers of planks affords

* Translated by L. L. Belinfante, B.Sc.

† "Die berggewerkschaftliche Versuchsstrecke zur Ergründung der Einwirkung von Sprengstoffen auf Schlagwetter und Kohlenstaub auf Zeche Consolidation Schacht I bei Schalke in Westfalen." *Glückauf*, 1894, pages 1651-1654.

very great resisting power, and renders the sides of the gallery as nearly impermeable as possible. With the view of securing this last condition, the edges of the planks, which have a breadth of 6 inches (150 millimetres), are displaced by one-third of their breadth from each other in the separate layers (Fig. 3, Plate XVI.).

The gallery is open at one end, and at the other end is fixed into a block of masonry 9·84 feet (3 metres) broad, 12·30 feet (3·75 metres) high, and 9·84 feet (3 metres) long, which encloses the gallery, within by 31½ inches (80 centimetres), and without by 43¼ inches (1·10 metres). In order to secure as firm a connexion as possible between the gallery and the masonry-block, three stout angle-irons (*a*) are bolted to the exterior of the framework of the gallery, as well as three bars (*b*) to the first five iron rings, and their recurved ends are anchored 6·56 feet (2 metres) into the masonry.

In the gallery at the working-face represented by the masonry block, two crucible-steel cannons are embedded; these are of a pattern similar to that used at Saarbrück. They consist of a core 6½ inches (165 millimetres) in diameter over which is drawn, when hot, a shell 19½ inches (495 millimetres) in diameter. In this core is the hole from which the shots are fired, and this is 18·11 inches (460 millimetres) long, and 2·16 inches (55 millimetres) in diameter (Figs. 5 and 6, Plate XVI.). Ring-handles are attached to both cannons so as to facilitate manipulation in setting the cannons into and out of their required positions. The cannons are bedded in sand, at the middle and lower portion of the face, at an angle so that a line prolonging the axis of the shot-holes touches the roof of the gallery at a distance of about 32·81 feet (10 metres) from the face. At the back, the cannons are cushioned with sheet indiarubber 1·38 inches (35 millimetres) thick, and willow-wood boards 2 inches (50 millimetres) thick.

The openings in the roof of the gallery, which may be closed by the plugs (*c*), 8 inches in diameter, act as safety-valves. The same purpose is served by the manhole (*d*) in the vicinity of the working-face. It is oval in section, and is closed by an iron sliding-shutter, which, when experiments are made with fire-damp, is luted with plastic clay.

The explosion-chamber for experiments with fire-damp is placed at the face, a wooden ring (*e*) is built at a distance of 16·73 feet (5·10 metres) from the working-face, over which strong brown paper is stretched by means of an annular iron spring (which is in contact both with the wooden ring and with the walls of the gallery), and in this way a space of 353 cubic feet (10 cubic metres) is partitioned off.

For ventilating the gallery after a shot has been fired, a cast-iron pipe (*f*) of 9·84 inches (250 millimetres) internal diameter is cemented into the masonry-block; it enters immediately below the roof of the gallery, and is connected with a Pelzer ventilator (20 inches in diameter) driven by a small steam-engine. This pipe can be closed inside the gallery by means of a wooden plug which exactly fits the cone-shaped opening of the pipe, and is so arranged that it can be removed from the other end of the pipe. By this means, there is no need to enter the gallery in order to connect it with the ventilator after the firing of a shot. The process of ventilating the gallery does not occupy more than six or seven minutes, even where the most dense fumes have been produced.

Fifteen sight-holes (*g*), placed on one side of the gallery at about three-fourths of its height, enable the observer to note what is going on inside. These sight-holes (Figs. 7 and 8, Plate XVI.) or windows consist of strong coupled iron frames containing small glass panes 1 inch (25 millimetres) thick. They are made taut inwardly with sheet asbestos and outwardly with sheet indiarubber, 0·71 inch (18 millimetres) thick; these materials act as cushions and tend to prevent the panes from being broken. Near the masonry-block, the distances between the sight-holes average about 3·28 feet (1 metre), while towards the open end of the gallery the distances are increased up to 8·2 feet (2·5 metres).

Opposite the sight-holes, and at a distance of 49·2 feet (15 metres), stands the observation-building. Here, in the wall which faces the gallery, is a slit through which a single observer may overlook the whole length of the gallery (Fig. 9, Plate XVI.).

The shots were electrically fired by a Bornhardt magneto-electric exploder placed in the observation-building. By means of two insulated copper wires, the exploder is connected with the two insulated copper knobs (*h*, h^1, Figs. 2 and 4, Plate XVI.), to which the ends of the conducting-wires from the electric detonators are connected.

The pit-gas used in the experiments was given off from an unworked seam G (rich in gas) of the Consolidation pit, belonging to the upper division of the bituminous coals. Between the 1,770 feet (540 metres) level and a level about 164 feet (50 metres) higher a rise-heading had been driven and a stopping inserted therein. In this stopping, a pipe is fixed and conveys the gas up the winding-shaft and over the pit-heap to the site of the experiments. The gas is stored in two cylindrical receivers (*b*) containing each about 212 cubic feet (6 cubic metres), and is drawn off as required by means of water-pressure. The arrangement

of the receivers and of the gas and water outlet and inlet-valves is shown in Fig. 10 (Plate XVI.), this is so contrived that the gas stored in one receiver may be drawn off whilst the other is being refilled. In order to determine exactly the amount of gas drawn off from the receivers, a gas-meter connected with the system of pipes is placed in the observation-building. The gas pipes enter at one-fifth of the height of the gallery at *m*, in the middle of the explosion-chamber (Figs. 2 and 4, Plate XVI.).

With the object of accelerating the diffusion of the gases (after their entry into the explosion-chamber) and their mixture with the atmospheric air, a fan consisting of two blades (*l*) is fixed to the roof of the gallery within the explosion-chamber at about three-quarters of its height: this can be set in rapid rotation by means of teethed-wheel gearing (*i*). By means of this simple fan, complete diffusion of the gases is effected in from four to five minutes, a result confirmed by the examination of samples of gas taken simultaneously at quarter, half, and three-quarters height of the gallery.

The fan is also used for inducing complete dispersion and a cyclonic whirling of the coal-dust within the explosion-chamber just before a shot is fired. For this purpose a pipe is placed in the roof of the gallery, opening into it just above the fan, and supports a vessel (*k*) containing about 122 cubic inches (2 litres). This vessel is filled with coal-dust, which is dropped directly on to the rapidly whirling fan. The wooden blades of the fan are protected from injury from the explosive blast by being placed, before the shot is fired, exactly in the line of the axis of the gallery, and, as a matter of fact, it is very rare that they have to be replaced.

This apparatus is, in its essentials, modelled upon that in use at the experimental gallery at the Wilhelm shaft of the Emperor Ferdinand Northern Railway Company at Polnisch-Ostrau.

II.—Experiments with Mining Explosives.*

The series of experiments made in the experimental gallery were designed to investigate the degree of security as against inflammation of fire-damp and coal-dust, afforded by the various explosives in use in the mining district of Dortmund. In an investigation of this description, the main object must evidently be to secure, under given conditions, results which are comparable one with the other. It does not matter so much of what kind these conditions are, so long as they are made as uniform as possible for all the various explosives in the several series of

* *Glückauf*, 1895, pages 559-562, 577-580, and 597-600.

experiments. But the possibility of making the shot-firing in the experimental gallery correspond exactly to the circumstances which obtain in practical mining work had to be considered as absolutely out of the question.

Nor can the degree of safety of a particular explosive be measured directly and solely from the results obtained with that explosive. One must, as a preliminary to forming a correct judgment, compare the whole of the results obtained with the several explosives, and bear in mind at the same time the experience which has been gained with them in dusty and fiery mines.

(1) *The Procedure of the Experiments.*

All the shots were fired without stemming from the borehole of the lower crucible-steel cannon (Figs. 2 and 3, Plate XVI.). In those cases, however, where the object was to observe the length of flame of an explosive, the upper cannon was used, because the opening of the borehole could be seen from the observation-building through the first window of the gallery.

The impalpable coal-dust used in the experiments, taken from the sweepings of the screening-apparatus of a bituminous coal-pit, was throughout obtained from the same source. Its uniformity was constantly checked by means of analyses and by comparative shots fired with a given quantity of an explosive whose ignition-limit was known. For this purpose, gelatine-dynamit was used in cartridges of 3·53 ounces (100 grammes) weight, it having previously been proved that this and no less quantity almost invariably ignited this coal-dust. The chemical analyses which, in common with all the other analyses mentioned in these pages, were carried out at the laboratory of the Westphalian Miners' Provident Society, in Bochum, showed that the composition of this coal-dust varied within very narrow limits, as proved by the analyses made on the following dates :—

	Sept. 19th, 1894.	Nov. 30th, 1894.	Dec. 27th. 1894.	Mar. 11th. 1895.	Mar. 22nd, 1895.
Coke	75	74·7	75·6	75·0	74·1
Volatile matter	23	22·6	22·7	22·0	23·0
Water	2	2·7	1·7	3·0	2·9
	100	100	100	100	100
Ash	5·5	5·3	5·3	5·1	6·3

Moreover the physical properties of the dust (fineness of state of division, etc.) were, as a consequence of its origin, uniform throughout.

In each experiment, a carefully-measured quantity of coal-dust, *i.e.*, 183 cubic inches (3 litres) was strewed over a length of 16·4 feet

(5 metres) of the gallery, from the inner end outwards, after the gallery had been carefully cleared of the dust remaining from the preceding experiment. Moreover, shortly before the shot was fired another charge of 122 cubic inches (2 litres) was scattered in the gallery by means of the fan.

When it was considered desirable to carry out experiments in explosive gaseous mixtures without the addition of coal-dust, the interior of the gallery was first of all carefully washed out by means of a jet of water under high pressure, and the same course was adopted whenever it was proposed to investigate the flames produced by the explosives. This precaution was found indispensable, because even the smallest accumulations of coal-dust in the crannies and crevices of the gallery-framework would more or less influence the appearances or the results observed.

The quantity of pit-gas introduced into the explosion-chamber of the gallery was measured by means of a 50 lights gas-meter placed in the observation-building. The time of inflow of the gases was made as uniform as possible, on the basis of about 5 cubic feet (150 litres) per minute. During the inflow of the gas the fan was made to revolve, and thus a continuous even mixture of air and gas was distributed throughout the explosion-chamber. By this means the superfluous air resulting from the inflow of gas, which escaped through rifts in the paper diaphragm shutting off the explosion-chamber, was always an uniform air-mixture, and was little, if at all, affected by the composition of the gaseous mixture present in the explosion-chamber. Samples of the gases were drawn off into testing-tubes of about 12 cubic inches (200 cubic centimetres) capacity by means of indiarubber piping passing through the roof of the gallery and having its aperture about the centre, and were in part submitted to chemical analysis.

These analyses showed that in cases where a small proportion of pit-gas was present, the content of pit-gas only varied slightly (0·10 to 0·05 and at most 0·20 per cent.) from the calculated percentage of marsh-gas, determined from the composition of the blower. This uniformity may be noted in the samples taken on the same day, as shown by the following table of samples:—

Date of Experiments. 1894.	Quantity of Gas introduced. Litres.	Cubic Ft.	Percentage of Marsh Gas.
September 25	800 ...	28·25 ...	5·80
	900 ...	31·78 ...	6·66
,, 28	900 ...	31·78 ...	7·10
	900 ...	31·78 ...	7·00
October 1	300 ...	10·59 ...	2·15
	300 ...	10·59 ...	2·10

Date of Experiments. 1894.	Quantity of Gas introduced. Litres.	Cubic Ft.	Percentage of Marsh Gas.
October 11	900 ...	31·78 ...	6·20
	900 ...	31·78 ...	6·30
„ 16	900 ...	31·78 ...	6·30
	900 ...	31·78 ...	6·20
„ 23	900 ...	31·78 ...	6·00
	300 ...	10·59 ...	2·10
November 5	300 ...	10·59 ...	2·31
	300 ...	10·59 ...	2·30
	300 ...	10·59 ..	2·34
1895.			
February 19	1,000 ...	35·32 ...	6·00
	1,000 ...	35·32 ...	6·20
	1,000 ...	35·32 ...	6·00
„ 22	1,100 ...	38·85 ...	7·00
	1,100 ...	38·85 ...	7·20
„ 28	1,100 ...	38·85 ..	6·90
	1,100 ...	38·85 ...	7·00
March 7	1,050 ...	37·08 ...	6·50
	1,050 ...	37·08 ...	6·70
„ 12	1,050 ...	37·08 ...	7·00
	1,050 ...	37·08 ...	7·00
	950 ...	33·55 ...	6·30
„ 15	1,050 ...	37·08 ...	6·50
	1,050 ...	37·08 ...	6·70
	1,050 ...	37·08 ...	6·70

The preceding table shows that great differences were observable only between samples taken on different days. It was therefore deemed unnecessary to analyse every sample, but care was taken to analyse, if possible, at least one sample on each day. The results yielded by that analysis were then taken as a criterion for the other samples.

Moreover, in experiments made with explosive gaseous mixtures, in order to obtain an immediate check, a further sample was drawn off in a Lohmann explosion-tube,* and the contents were ignited by means of the passage of an electric spark. With a little practice the proportion of marsh gas may be gauged to within ½ per cent., merely from the violence of the fire-damp explosion which takes place in the tube.

The great variation between samples taken on different days may fairly be attributed to the want of uniformity in the quantity of fire-damp present in the pit-gas. For example, this contained of marsh gas:—

1894, September 13	84 per cent.
„ February 21	75 „
1895, April 2	80 „

* *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, vol. xxxvii., page 87.

When it was desired to make experiments in the simultaneous presence of coal-dust and fire-damp mixtures, the dust was strewed along the floor of the gallery before the partitioning off of the explosion-chamber, and the addition of further coal-dust to the air was effected after the gases had been introduced, and a little before the shot was fired.

In order to take account of the possible influence of variations in temperature, the temperature of the interior of the gallery, as well as that of the coal-dust, was ascertained before every experiment. Unfortunately, it was impracticable to arrange absolutely uniform conditions of temperature, because the temperature of the gallery depended on whether in the course of the experiments ignition was more or less frequently produced. After the construction of a heating-apparatus* it was, however, found possible to regulate in some degree the temperature, so that it rarely fell below 59 degs. Fahr. (15 degs. Cent.), and rarely exceeded 68 degs. Fahr. (20 degs. Cent.). Indeed, within these limits, no difference as regards the results obtained was observable.

Finally, we may mention that it was sought to neutralize the effects of the weather (favourable or not) by experimenting as far as possible in close succession with explosives of similar character: for example, westfalit and dahmenit. The results thus obtained with the different explosives did not show that the weather had any marked effect.

(2) *The Programme of Experiments.*

In order to investigate as accurately as possible the properties of the various explosives, and in particular their behaviour in presence of fire-damp or coal-dust, or in mixtures of fire-damp and coal-dust, every explosive was subjected to the following series of experiments:—

1. Firing of a shot from the upper cannon in the absence of fire-damp and coal-dust, so as to observe the breadth and length of the flame.

2. Firing of a series of shots with varying weights of explosive in order to determine the smallest amount which could, under the following conditions, ignite the explosive gaseous mixture, provided that such ignition could be produced by the heaviest charges which it was possible to introduce into the cannon, say 18 to 21 ounces (500 to 600 grammes).

(a) In presence of coal-dust strewed in the gallery and suspended in the air, without any fire-damp being present.

* The heating-apparatus consists of two wrought-iron tubes 16·4 feet (5 metres) long, 2 inches (0·05 metre) in internal diameter, connected to the main steam-pipes. These tubes rest on strong iron chairs, about 2 feet from the bottom of the gallery, and are carried along the walls into the explosion-chamber. They can be supplied with steam as desired.

(*b*) In the midst of an explosive mixture containing 6 to 7 per cent. of fire-damp, without any coal-dust being present.

(*c*) In the midst of a mixture containing fire-damp, coal-dust being at the same time strewed in the gallery and in suspension in the air.

(*aa*) In presence of a gaseous mixture, such that the proportion of marsh gas present is just recognizable with a safety-lamp, say about $2\frac{1}{4}$ per cent. of fire-damp.

(*bb*) In presence of an explosive gaseous mixture containing 6 to 7 per cent. of fire-damp.

With those explosives which, in presence of $2\frac{1}{4}$ per cent. of fire-damp, did not, even with heavy charges of as much as 18 ounces (500 grammes), ignite the coal-dust, further experiments were made in presence of gaseous mixtures richer in fire-damp (say 5 per cent. of marsh gas), yet not in themselves explosive, coal-dust being strewed and in suspension as before.

(3) *The Explosives used in the Experiments.*

As the main object of the experiments was to investigate closely the behaviour of the so-called safety-explosives, the investigation as regards these was made as thorough as possible, while the explosives which are not ranged in the safety category were included in the series of experiments only so far as they might elucidate by comparison the conclusions to be arrived at concerning safety-explosives. Blasting-powder was altogether excluded, because the earlier investigations of the Prussian Fire-damp Commission had shown that it was highly dangerous in all fiery and dusty mines, and is therefore nowadays no longer allowed to be used in such mines.

The substances which came into purview were:—

I.—Among the non-safety explosives:—

1. Gelatine-dynamit.
2. Guhr-dynamit.
3. Gesteins-carbonit (stonite).*

II.—As safety-explosives:—

1. Wetter-dynamit, from the Schlebusch dynamite factory, consisting of† trinitro-glycerine, 52·9 per cent.; sulphate of magnesia (Epsom salts, $MgSO_4 + 7\ H_2O$), 32·7 per cent.; kieselguhr, 14·4 per cent.

* According to the manufacturer, this consists of nitro-glycerine, 68·0 per cent.; kieselguhr, 17·0 per cent.; nitrate of potassium, 10·5 per cent.; ryemeal, 3·5 per cent.; soot, 1·0 per cent.

† According to analyses made by the Director of the Provident Society's Laboratory (Dr. Broockmann of Bochum).

2. Carbonit (coal) which (according to the manager of the Schlebusch carbonite factory) consists of nitro-glycerine, 25·0 per cent.; nitrate of potassium, 34·0 per cent.; ryemeal, 38·5 per cent.; woodmeal, 1·0 per cent.; nitrate of barium, 1·0 per cent.; bicarbonate of sodium, 0·5 per cent. The chemical analysis of a sample showed that the proportion of nitro-glycerine was 29·5 per cent.

3. Sekurit from the Köln-Rottweil powder factories, consisting of* mono-' and dinitro-benzol, 29 per cent.; nitrate of ammonium, 37 per cent.; nitrate of potassium, 34 per cent.

4. Roburit from the roburit factory of Witten on the Ruhr, consisting of* dinitro-benzole, 17·8 per cent.; nitrate of ammonium, 79·2 per cent.; chloride of ammonium and sulphate of ammonium, 0·3 per cent.; water (damp arising from long storage of the sample), 2·7 per cent.

5. Westfalit from the westfalit factory at Sinsen (belonging to the Westphalian-Anhalt Explosive Company), consisting of* nitrate of ammonium, 94·0 per cent.; resin, 5·4 per cent.; chloride of ammonium, 0·1 per cent.; sulphate of ammonium, 0·4 per cent.; impurities, 0·1 per cent.

6. Dahmenit from the Castrop Safety-explosive Company, consisting of* nitrate of ammonium, 93·3 per cent.; naphthalene, 4·8 per cent.; chlorate of potassium, 1·6 per cent.; chloride of ammonium, 0·1 per cent.; sulphate of ammonium, 0·2 per cent.

7. Progressit from the roburit factory at Witten on the Ruhr, consisting of* nitrate of ammonium, 89·1 per cent.; hydrochlorate of aniline, 4·7 per cent.; sulphate of ammonium, 6·0 per cent.; impurities, 0·2 per cent.

The samples of explosives which formed the material for investigation were invariably taken from the stores of various mines, the sekurit alone being obtained direct from the manufacturers, as there was no other available source of supply.

(4) *Preliminary Experiments.*

1. Preliminary experiments with gaseous mixtures containing fire-damp in order to test the uniformity of the mixtures made by the fan.

For this purpose a number of experiments were arranged with a mixture which was just barely explosive, that is, contained something like 6 per cent. of fire-damp. And in order to test the uniformity of this mixture, the ends of the copper-wires (used in the firing of the

* According to analyses made by the Director of the Provident Society's Laboratory (Dr. Broockmann of Bochum).

shots) were brought into the proximity of the aperture of the borehole in the lower cannon with their ends at a distance of about 0·20 inch (5 millimetres) apart. When thereupon an electric spark was made to jump across with the aid of the magneto-electric exploder, a feeble explosion of the fire-damp mixture followed regularly, proving that even at a spot most remote from the inflow of the gas an explosive mixture of gas was present, and that therefore the mixture was complete. Further, several samples were taken simultaneously from different heights in the gallery,* and they invariably yielded uniform results, as shown by the following example:—

Date of taking of Sample.	Sample from.	Duration of Running of Fan.	Quantity of Gas Used.		Results of Analyses, Fire-damp.
1894.			Litres.	Cubic Ft.	Percentage.
September 13 ...	¼ height				6·00
,, ...	½ ,,	6 minutes	800	28·25	6·00
,, ...	¾ ,,				6·00
,, 19 ...	¼ ,,				2·20
,, ...	½ ,,	3½ minutes	310	10·95	2·35
,, ...	¾ ,,				2·30

2. Experiments with detonators.

In the firing of the charges Bornhardt electric detonators alone were used. In order to test whether a single detonator was sufficient to ignite fire-damp mixtures, a number of detonators, as tabulated below, partly hanging free, partly tied together by half-dozens within the front portion of the borehole in the cannon, were caused to explode in gaseous mixtures containing from 6½ to 9 per cent. of marsh gas. No ignition of fire-damp ever took place:—

No. 3 detonator, containing	8·3	grains, or	0·54	grammes,	of fulminate of mercury.		
No. 6 ,, ,,	15·4	,,	1·00	,,	,,	,,	
No. 7 ,, ,,	23·1	,,	1·50	,,	,,	,,	
No. 8 ,, ,,	30·8	,,	2·00	,,	,,	,,	

3. Experiments for determining the inflammability of the paper diaphragm, which was used to form an explosion-chamber at a distance of 16·73 feet (5·10 metres) from the face of the gallery.

As it did not seem at all impossible that the paper which formed the partition-wall of the explosion-chamber might be ignited by the flame from the shot-firing, and that thereby the observed results might be

* The samples were obtained by fixing to the roof of the gallery a rubber plug, in which three holes were bored. Through these holes were passed rubber tubes opening at respectively ¼, ½, and ¾ height above the floor of the gallery.

affected, a series of experiments were carried out with gelatine-dynamit and safety-explosives in the absence of coal-dust and in the presence of fire-damp mixtures, such as were not explosive in themselves, but might well cause a lengthening of the flame. It was proved that the paper partition set up at a distance of 16·73 feet. (5·10 metres) from the face of the gallery could not possibly be set on fire, even though one used such heavy charges as 10·58 ounces (300 grammes) of safety-explosive and 5·29 ounces (150 grammes) of gelatine-dynamit in the presence of $4\frac{1}{2}$ per cent. of fire-damp. It was therefore considered needless to concern oneself about a preliminary impregnation of the partition-wall with such substances as might protect it from ignition.

4. At the very beginning of the experiments it was found that with safety-explosives extremely diverse results were obtained, according as the charge of explosive reached up to the aperture of the borehole of the cannon or lay at the bottom of it, and according as a free space of varying length was left in front of the cartridge. In the first case the conditions appeared much the most dangerous. This applies, with cartridges of 1·18 to 1·38 inches (30 to 35 millimetres) diameter, even to charges of 14·11 ounces (400 grammes). Now, as it was impracticable with many explosives, and in particular with the plastic nitro-glycerine varieties, by filling the material into cartridges of larger diameter, to put these deep down into the borehole, and as it was found that with heavy charges the cartridges always reached right up to the aperture, a series of experiments was first carried out with every one of the explosives. In these experiments the cartridges were so set within the cannon that they exactly coincided with the foremost edge of the borehole. Precisely identical conditions were arranged for each explosive, and for any selected charge. Of course such experiments cannot be claimed as approaching in any way the conditions which actually obtain in the mine, but it was necessary to make them in order to get comparable results for such explosives as were fired in large quantities in the original cartridges. The results, however, enable one to see what quantity of an explosive, under the most unfavourable conditions, is capable of igniting an atmosphere in which fire-damp and coal-dust are present.

Another series of experiments was undertaken, wherein the explosive charges were simply placed on the bottom of the borehole, leaving in front of them a free space of about 6 inches (150 millimetres) in length. No stemming was used in these experiments, as in the previous series. The study of the effects of stemming was reserved for a special set of experiments.

(5) *Results of the First Series of Experiments.*

With regard to the first series of experiments, wherein the explosive was placed in the foremost portion of the cannon, we may remark:—

1. That flame-phenomena, more or less considerable, were observable in the case of every explosive. Those of greater intensity were noticed with gesteins-carbonit, guhr-dynamit, and gelatine-dynamit. The safety-explosives gave rise only to short flames, and with carbonit only a feeble flash of light was observed.

2. From the point of view of their behaviour in presence of coal-dust without fire-damp, gelatine-dynamit, sekurit, guhr-dynamit, and gesteins-carbonit are to be regarded as by far the most dangerous. Charges of about 3·53 to 4·41 ounces (100 to 125 grammes) almost invariably sufficed to ignite a dusty atmosphere.

Roburit* and wetter-dynamit proved much more reliable. With these explosives the coal-dust was ignited only by a charge of 10·58 to 12·35 ounces (300 to 350 grammes).

The explosives westfalit and dahmenit, the cartridge-cases of which had been strongly steeped in resin, paraffin, or ceresin, to protect them against damp, and were used, still in the original coverings, in ordinary working, ignited coal-dust as soon as the charge reached about 8·82 ounces (250 grammes). But if the explosive, instead of being enclosed in a paraffined covering was simply wrapped in an ordinary paper one, ignition of coal-dust did not take place, even with charges as heavy as 17·46 ounces (495 grammes).

With progressit the dangerous influence of the paraffined cartridge-cases was not at first noticed.† The biggest charges which could be placed in the cannon in the original cases (that is 15·88 ounces or 450 grammes) failed to ignite coal-dust. The same observation applies to carbonit.

3. In the presence of gaseous mixtures containing small percentages of fire-damp (say about $2\frac{1}{4}$ per cent. of marsh gas) the safety of the greater number of explosives was found to diminish in a very remarkable degree. The accompanying table shows the smallest quantity of the

* The roburit which formed the material under investigation was packed exclusively in so-called double cartridges. These consist of a paper case containing the explosive, which was enclosed in a second covering, strongly steeped in ceresin. The instructions issued by the manufacturers state that this second covering is to be removed before making use of the explosive, and this was accordingly done in carrying out the experiments.

† Compare, however, the later experiments with progressit.

several explosives which would produce ignition. Progressit and carbonit proved in this case also to be safe in charges of 14·11 to 15·88 ounces (400 to 450 grammes) :—

Name of Explosive.	Weight of Explosive. Ounces.	Grammes.
Gelatine-dynamit	2·65 ...	75
Guhr-dynamit	2·65 ...	75
Gesteins-carbonit	3·92 ...	111
Sekurit	1·76 ...	50
Roburit	5·36 ...	152
Wetter-dynamit	7·05 ...	200
Westfalit*	10·58 ...	300
Dahmenit*	12·35 ...	350

4. In explosive gaseous mixtures containing high percentages of fire-damp (say 6¼ to 7 per cent. of marsh gas) the following minimum charges of the various explosives sufficed to bring about ignition. No essential difference in regard to ignition was noticed when coal-dust was strewed at the same time, and such differences as were observable may be attributed to purely accidental circumstances :—

Name of Explosive.	Weight of Explosive.		Pit-gas without Coal-dust. Percentage of Marsh Gas.	Weight of Explosive.		Pit-gas with Coal-dust. Percentage of Marsh Gas.
	Ounces.	Grams.		Ounces.	Grams.	
Gelatine-dynamit ...	1·76	50	6·20	1·58	45	6·50
Guhr-dynamit ...	2·05	58	6·50	1·06	30	6·80
Gesteins-carbonit ...	2·86	81	7·00	—	—	—
Sekurit	5·29	150	6·40	—	—	—
Wetter-dynamit ...	2·40	68	6·30	1·80	51	6·60
Roburit...	5·43	154	6·10	4·59	130	5·80
Westfalit*	8·85	251	7·00	8·82	250	6·30
Dahmenit*	8·85	251	7·10	8·82	250	6·30
Progressit*	19·40	550	6·75	19·76	560	7·25

Carbonit, even in charges of 21·17 ounces (600 grammes), and in the presence of 7·3 per cent. of marsh gas, did not produce any explosion of fire-damp.

In the Appendix, the separate experiments are systematically arranged in accordance with the principles laid down in the programme of experiments.

(6) *Results of the Second Series of Experiments.*

In the second series of experiments, wherein the explosive was set down on the bottom of the borehole in the cannon, so that in front of it was left a free space of about 6 inches (150 millimetres) in length, the

* Repacked into non-paraffined cartridge-cases.

interesting result was obtained that this open borehole did not have a similarly favourable effect with all explosives. Every one of the safety-explosives, with the exception of carbonit, was experimented with. The last-named had to be excluded from this series, because the quantity of explosive in the original packages always filled the borehole up to the very end, and, as previously remarked, a repacking of the explosive into cartridges of larger diameter was held to be impracticable as well as dangerous on account of the contained nitro-glycerine. But on the other hand, a new explosive, namely, dahmenit A* was included in this second series of experiments.

Of non-safety explosives, gelatine-dynamit alone was experimented with.

On comparing Table A, sections 1 and 6, with Table B, sections 11 and 12 (Appendix), it will be seen that, in the case of gelatine-dynamit and roburit, no difference as to the quantity necessary for producing ignition of the explosive atmosphere could be observed between the two series of experiments. So that the open borehole was of no effect on these explosives at all events. Moreover, the chemical properties of guhr-dynamit, gesteins-carbonit, and sekurit lead one to infer that these also would have shown results coinciding with those obtained in the first series.

The other safety-explosives gave much more favourable results than on previous occasions, especially in the presence of coal-dust and gaseous mixtures containing small percentages of fire-damp. In explosive fire-damp mixtures, however, no essential difference was noted as compared with the first series.

With wetter-dynamit, even charges of 16·23 ounces (460 grammes) failed to produce ignition of coal-dust. Even in the presence of $2\frac{1}{4}$ per cent. of fire-damp in addition, the ignition of the dust only took place with charges approaching 12·35 ounces (350 grammes).

Westfalit and dahmenit in the original paper cartridges showed no difference from the previous results.† But in cartridges which had been repacked, they both proved perfectly safe as regards coal-dust up to charges of 15·88 ounces (450 grammes), even in presence of $2\frac{1}{4}$ per cent.

* Dr. Broockmann analysed a sample, which had the following composition :— Nitrate of ammonium, 91·4 ; naphthalene, 5·2 ; bichromate of potash, 2·6 ; water, chloride of ammonium, etc., 0·8.

† The apparently less favourable results with westfalit are in all probability due to the rather stronger impregnation with paraffin of the paper coverings of the cartridges.

of fire-damp. Ignition of the coal-dust only took place with about 5 per cent. of fire-damp and charges of 10·58 and 12·35 ounces (300 and 350 grammes) respectively.

Progressit behaved in what, at first sight, appeared to be an extraordinary fashion. Whereas in the first series of more critical experiments ignition was only produced with charges varying between 16·76 and 19·40 ounces (475 and 550 grammes), and in presence of gaseous mixtures containing a high percentage of fire-damp (bearing in mind also that the original paraffined coverings in which the explosive was enclosed tended to promote ignition)—now ignition of the coal-dust in suspension in the atmosphere was obtained almost invariably with only 12·35 ounces (350 grammes) of explosive and in the complete absence of fire-damp. These strangely discordant results, however, are solely attributable to an alteration in the chemical composition of the explosive. Thus the chemical analysis of a sample demonstrated that the proportion of hydrochlorate of aniline had been increased from 4·6 to 5·5 per cent., while that of sulphate of ammonium had been diminished from 6 to 2·3 per cent.* On the other hand, without the paraffined paper covering, the explosive showed once more a high degree of safety.

The newest of the explosives, dahmenit A, turned out to be a very safe one. Even paraffined-paper cartridge-cases seemed to do nothing towards helping ignition, and the charges had to be increased up to 19·76 or 20·11 ounces (560 or 570 grammes), and the presence of as much as 7 per cent. of fire-damp arranged in order to produce ignition. Smaller charges, even in so fiery a gaseous mixture and in paraffined cases, failed to ignite coal-dust.

Conclusions.

The curiously dissimilar behaviour of the various explosives in both series of experiments can only be explained somewhat as follows:—

The explosives which show in the second series results in nowise differing from those obtained in the first series of experiments, develop a flame of magnitude such that a free space of 6 to 7 inches (150 to 180 millimetres) in front of the explosive in the hole does not suffice to quench or deaden the flame sufficiently to prevent the ignition of the inflammable atmosphere. On the other hand, the protective effect of

* An analysis of samples showed nitrate of ammonium, 92·2; hydrochlorate of aniline 5·5; sulphate of ammonium, 2·3. It is therefore evident that the progressit which is put on the market varies considerably in chemical composition.

this free space must be very noticeable in the case of extremely short-flame safety-explosives, such as wetter-dynamit, westfalit, and dahmenit. With the last two, for instance, only in presence of 5 per cent. of fire-damp was the flame lengthened sufficiently to come into contact with the explosive atmosphere and ignite it. The experiments with inflammable gaseous mixtures show on the face of them that the extremely favourable results obtained with such explosives are solely attributable to this shortness of flame. For in these experiments, the fire-damp of course diffusing into the open borehole and the flame of the explosive finding within that free space an inflammable atmosphere ready to hand, an explosion was produced which travelled into the interior of the gallery, and so the results could not show any difference from those obtained in the first series of experiments. The correctness of this explanation may be further inferred on looking at the results of experiments Nos. 1 to 5 in Table C (Appendix). When even a very small quantity of coal-dust was strewed within the borehole in front of the explosive, ignition of the dust-laden atmosphere was once more obtained with westfalit and dahmenit in presence of $2\frac{1}{4}$ per cent. of fire-damp, despite the free space of about 7 inches (170 to 180 millimetres) in length, and this with charges which practically corresponded to those found necessary in the first series of experiments. In such cases an inflammable mixture was thus present inside the borehole within reach of the flame produced by the shot.

As to the special influence of impregnation of the paper cartridge-cases with paraffin or ceresin, the following explanation would probably apply:—

The temperature developed on detonation of the explosive is so high that the paraffin on the cartridge-cases is vapourized and ignited. In consequence thereof a longer and hotter flame is developed, which, even with small charges of explosive, is quite capable of igniting the coal-dust-laden atmosphere. This view appears to be confirmed by the experiments with progressit (of the original composition) and dahmenit A. Both explosives proved extremely safe as well in presence of fire-damp mixtures as in that of coal-dust. The temperatures developed on detonation of these explosives must be comparatively low, so low, in fact, that the paraffin on the paper cartridge-cases does not take fire. Thus it is evident that the paraffin has no unfavourable effect with these explosives.

An interesting observation may be noted with regard to progressit. In the experiments wherein this explosive showed so high a degree of safety, ignition was in no wise promoted by the paraffin on the paper

cartridge-cases. But so soon as the safety of the explosive was diminished by reason of its altered chemical composition, the temperature of detonation being therefore heightened, the influence of the original paper cartridge-cases was once more observable. Whether with stemmed shots that influence is equally damaging cannot be affirmed in the absence of further evidence. For this a more detailed investigation is required, and it will be carried out as soon as the cannon which has to be used for such investigations is provided with a deeper and narrower borehole. The results of this further investigation will be published shortly.

The detonating force, too, of an explosive is an important factor to bear in mind when considering the advantages or otherwise of using that explosive in a mine, and the experiments are to be supplemented in that direction also. These results will also be published as soon as they are completed.

APPENDIX.

TABLE A.—FIRST SERIES OF EXPERIMENTS.

REFERENCES: I, ignition; N, non-ignition.

1. GELATINE-DYNAMIT.*

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Temperatures. Of the Gallery. Cent.	Temperatures. Of the Coal-dust. Fahr.	Temperatures. Of the Coal-dust. Cent.	Results.
	1894.	Oz. Grms.			%					
1	Aug. 9	1·80 51	Original.	Nil.	Nil.	59	15	..	..	*a*
2	,, 9	3·53 100	,,	With coal-dust.	,,	59	15	59	15	I
3	,, 9	2·65 75	,,	,,	,,	59	15	59	15	N
4	,, 9	3·56 101	,,	,,	,,	59	15	59	15	I
5	Sept. 21	3·56 101	,,	,,	,,	61	16	59	15	N
6	Oct. 31	1·76 50	,,	,,	2·20	46	8	52	11	N
7	,, 31	2·65 75	,,	,,	2·20	54	12	52	11	I
8	Aug. 16	1·58 45	,,	,,	6·50	..	..	..	..	I
9	Sept. 25	1·76 50	,,	Nil.	6·20	59	15	..	..	I

* Ignited with No. 3 detonator. *a* Light red flames, 12 feet (3·5 metres) long.

2. GUHR-DYNAMIT.*

	1894.	Oz. Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Sept. 20	2·47 70	Original.	Nil.	Nil.	59	15	..	..	*a*
2	,, 20	5·33 151	,,	With coal-dust.	,,	59	15	64	17½	I
3	,, 20	4·44 126	,,	,,	,,	60	15½	64	17½	N
4	,, 20	4·41 125	,,	,,	,,	60	15½	64	17½	I
5	,, 21	3·88 110	,,	,,	,,	60	15½	61	16	N
6	Nov. 12	2·82 80	,,	,,	2·25	52	11	52	11	I
7	,, 12	2·65 75	,,	,,	2·25	52	11	52	11	I
8	Sept. 22	1·76 50	,,	,,	6·20	59	15	59	15	I
9	,, 22	1·06 30	,,	,,	6·80	59	15	59	15	I
10	,, 25	2·05 58	,,	Nil.	6·10	52	11	..	..	I

* Ignited with No. 3 detonator. *a* Flames, 8·2 feet (2·5 metres long.

3. GESTEINS-CARBONIT (STONITE).*

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery.		Temperatures. Of the Coal-dust.		Results.
	1894.	Oz.	Grms.		%	Fahr.	Cent.	Fahr.	Cent.	
1	Oct. 20	1·41	40	Original.	Nil.	45	7	..	..	*a*
2	,, 20	7·05	200	,,	With coal-dust.	,,	46	8	46	8	I
3	,, 20	3·67	104	,,	,,	,,	50	10	46	8	N
4	,, 20	5·33	151	,,	,,	,,	50	10	46	8	I
5	,, 20	4·66	132	,,	,,	,,	54	12	46	8	I
6	,, 20	4·34	123	,,	,,	,,	54	12	46	8	I
7	,, 20	2·12	60	,,	,,	2·25	52	11	46	8	N
8	,, 23	3·92	111	,,	,,	2·10	52	11	50	10	I
9	,, 26	2·86	81	,,	Nil.	7·00	52	11	..	..	I

* Ignited with No. 6 detonator. *a* Very bright flame, 13 feet (4 metres) long.

4. SEKURIT.*

	1894.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Sept. 29	3·53	100	Original.	Nil.	Nil.	46	8	..	..	*a*
2	,, 29	7·20	204	,,	With coal-dust.	,,	49	9½	49	9½	I
3	,, 29	5·29	150	,,	,,	,,	51	10½	49	9½	I
4	,, 29	3·53	100	,,	,,	,,	55	12½	49	9½	I
5	Oct. 1	3·53	100	Repacked in ordinary cartridge paper.	,,	,,	49	9½	50	10	I
6	,, 1	1·76	50	,, ,,	,,	,,	49	9½	50	10	N
7	,, 1	1·76	50	,, ,,	,,	2·10	50	10	50	10	I
8	,, 1	1·06	30	,, ,,	,,	2·10	55	13	50	10	N
9	,, 2	3·53	100	Original.	Nil.	6·50	50	10	..	..	N
10	,, 2	7·05	200	,,	,,	6·40	54	12	..	..	I
11	,, 3	5·29	150	,,	,,	6·40	52	11	..	..	I

* Ignited with No. 6 detonator. *a* Flame at the first window.

5. WETTER-DYNAMIT.*

	1894.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Sept. 19	2·72	77	Original.	Nil.	Nil.	55	12½	..	..	*a*
2	,, 19	11·29	320	,,	,,	,,	55	12½	..	..	*b*
3	,, 19	5·29	150	,,	With coal-dust.	,,	58	14½	64	17½	N
4	,, 19	8·82	250	,,	,,	,,	58	14½	64	17½	N
5	,, 19	12·07	342	,,	,,	,,	59	15	64	17½	I
6	,, 19	10·83	307	,,	,,	,,	61	16	64	17½	N
7	,, 19	11·50	326	,,	,,	,,	66	19	64	17½	N
8	,, 19	12·03	341	,,	,,	,,	63	17	66	19	N
9	,, 19	12·21	346	,,	,,	,,	63	17	66	19	N
10	,, 19	13·09	371	,,	,,	,,	63	17	66	19	I
11	,, 19	12·42	352	,,	,,	,,	61	16	..	..	N
12	,, 21	12·38	351	,,	,,	,,	61	16	64	17½	I
13	,, 21	10·69	303	,,	,,	,,	61	16	63	17	N
14	Oct. 11	3·81	108	,,	,,	2·10	62	16½	52	11	N
15	,, 31	5·71	162	,,	,,	2·20	54	12	54	12	N
16	Nov. 5	8·99	255	,,	,,	2·31	57	14	54	12	I
17	,, 5	7·05	200	,,	,,	2·31	57	14	54	12	I
18	,, 5	7·05	200	,,	,,	2·20	57	14	54	12	I
19	,, 5	5·47	155	,,	,,	2·25	59	15	54	12	N
20	,, 5	8·99	255	,,	,,	1·50	57	14	54	12	N
21	Oct. 16	1·90	54	,,	,,	6·30	46	8	50	10	N
22	,, 16	2·40	68	,,	,,	6·30	46	7½	50	10	I
23	Sept. 25	5·29	150	,,	Nil.	6·60	58	14½	..	..	I
24	,, 25	3·56	101	,,	,,	6·60	61	16	..	..	I
25	,, 25	1·80	51	,,	,,	6·60	64	18	..	..	I
26	Nov. 10	1·75	49½	,,	,,	7·20	46	7½	..	..	I

* Ignited with No. 3 detonator. *a* No flame observed. *b* Flame at first window.

6. ROBURIT.*

No. of Experiment.	Date.	Explosive. Weight.	Grms.	Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Cent.	Of the Coal-dust. Fahr.	Cent.	Results.
	1894.	Oz.				%					
1	Aug. 11	2·82	80	Original.	Nil.	Nil.	57	14	..	..	*a*
2	,, 17	5·40	153	After taking off the outer covering.	With coal-dust.	,,	..	..	..	..	N
3	,, 17	11·64	330	,, ,,	,,	,,	..	..	..	..	I
4	Oct. 13	8·82	250	,, ,,	,,	,,	54	12	50	10	N
5	,, 13	10·58	300	Repacked in ordinary cartridge paper.	,,	,,	57	14	52	11	I
6	,, 13	9·70	275	,, ,,	,,	,,	59	15	52	11	N
7	,, 18	10·58	300	,, ,,	,,	,,	50	10	50	10	N
8	,, 18	10·58	300	,, ,,	,,	,,	50	10	50	10	I
9	,, 24	6·28	178	,, ,,	,,	2·40	46	8	46	8	I
10	,, 24	4·27	121	,, ,,	,,	2·40	52	11	50	10	N
11	,, 24	5·36	152	,, ,,	,,	2·40	52	11	50	10	I
12	,, 23	4·59	130	,, ,,	,,	5·80	43	6	50	10	I
13	,, 22	7·05	200	,, ,,	Nil.	6·10	48	9	..	..	I
14	,, 22	5·43	154	,, ,,	,,	6·10	50	10	..	..	I
15	,, 22	3·67	104	,, ,,	,,	6·10	54	12	..	..	N

* The explosives roburit, westfalit, and dahmenit were ignited with Nos. 6, 7, or 8 detonators, according as these were in a more or less fresh (unaltered) condition.

a Flame at the second window, 8 feet (2·5 metres) long.

7. WESTFALIT.*

	1894.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Sept. 26	3·53	100	Original.	Nil.	Nil.	59	15	..	..	*a*
2	Aug. 17	9·42	267	,,	With coal-dust.	,,	..	..	..	..	N
3	,, 17	11·75	333	,,	,,	,,	..	..	..	..	I
4	Sept. 26	10·41	295	,,	,,	,,	61	16	64	17½	I
5	,, 26	8·82	250	,,	,,	,,	64	18	64	17½	I
6	,, 26	7·69	291	,,	,,	,,	64	18	64	17½	N
7	Oct. 8	9·13	259	,,	,,	,,	58	14½	59	15	I
8	,, 8	9·56	271	Repacked in non-paraffined paper.	,,	,,	58	14½	59	15	N
9	,, 8	14·11	400	,, ,,	,,	,,	61	16	59	15	N
10	Sept. 26	17·50	496	,, ,,	,,	,,	64	17½	64	17½	N
11	Nov. 3	16·76	475	,, ,,	,,	,,	..	..	..	..	N
12	Oct. 9	8·82	250	,, ,,	,,	2·10	46	8	48	9	N
13	,, 9	10·58	300	,, ,,	,,	2·10	46	8	54	12	I
14	Nov. 2	11·45	325	,, ,,	,,	2·20	55	13	54	12	N
15	,, 5	12·38	351	,, ,,	,,	2·34	57	14	54	12	I
16	Dec. 5	12·49	354	,, ,,	,,	2·25	57	14	59	15	N
17	,, 5	12·56	356	,, ,,	,,	2·25	57	14	59	15	I
18	,, 5	12·63	358	,, ,,	,,	2·25	59	15	59	15	I
19	Oct. 11	7·05	200	,, ,,	,,	6·20	52	11	50	10	N
20	,, 11	8·82	250	,, ,,	,,	6·20	52	11	55	12½	I
21	Sept. 28	7·05	200	,, ,,	Nil.	7·00	52	11	..	..	N
22	,, 28	8·85	251	,, ,,	,,	7·00	58	14½	..	..	I
23	Oct. 9	8·82	250	,, ,,	,,	6·30	60	15½	..	..	N
24	,, 9	10·58	300	,, ,,	,,	6·30	46	7½	..	..	I
25	,, 11	8·82	250	,, ,,	,,	6·30	47	8½	..	..	I
26	,, 8	7·05	200	Original.	,,	6·30	60	15½	..	..	I
27	,, 8	5·29	150	,,	,,	6·30	61	16	..	..	N

a Flame at the first window.

8. DAHMENIT.*

No. of Experiment.	Datt.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Temperatures. Of the Gallery. Cent.	Temperatures. Of the Coal-dust. Fahr.	Temperatures. Of the Coal-dust. Cent.	Results.
	1894.	Oz.	Grms.		%					
1	Sept. 26	3·53	100	Original.	Nil.	59	15	..	..	*a*
2	,, 26	10·37	294	,,	With coal-dust.	59	15	64	17½	I
3	,, 26	8·82	250	,,	,,	64	17½	64	17½	I
4	,, 26	7·09	201	,,	,,	64	18	63	17	N
5	,, 26	12·42	352	Repacked in non-paraffined paper.	,,	64	17½	63	17	N
6	,, 26	17·50	496	,, ,,	,,	64	18	63	17	N
7	Oct. 1	12·70	360	,, ,,	,,	2·15	55	12½	50	10	I
8	Dec. 4	12·35	350	,, ,,	,,	2·25	54	12	57	14	N
9	,, 4	12·56	356	,, ,,	,,	2·25	57	14	59	15	I
10	,, 4	12·66	359	,, ,,	,,	2·25	66	19	59	15	I
11	,, 4	12·49	354	,, ,,	,,	2·27	65	18½	59	15	I
12	,, 4	10·62	301	,, ,,	,,	2·25	64	18	59	15	N
13	Oct. 11	8·82	250	,, ,,	,,	6·30	60	15½	52	11	I
14	,, 11	7·05	200	,, ,,	,,	6·30	64	17½	52	11	N
15	Sept. 27	5·29	150	,, ,,	Nil.	6·50	57	14	..	..	N
16	,, 27	7·05	200	,, ,,	,,	7·00	52	11	..	..	N
17	,, 27	8·85	251	,, ,,	,,	7·10	57	14	..	..	I
18	Oct. 5	9·70	275	,, ,,	,,	6·40	52	11	..	..	N

* The explosives roburit, westfalit, and dahmenit were ignited with Nos. 6, 7, or 8 detonators, according as these were in a more or less fresh (unaltered) condition.

a Flame at the first window.

9. PROGRESSIT.*

	1894.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Oct. 29	15·52	440	Original.	With coal-dust.	Nil.	48	9	50	10	N
2	,, 5	14·11	400	,,	,,	2·25	54	12	52	11	N
3	,, 29	15·52	440	,,	,,	6·50	54	12	52	11	N
4	,, 29	15·52	440	,,	,,	7·25	54	12	52	11	N
5	,, 31	19·23	545	Repacked in non-paraffined paper.	,,	6·50	59	15	54	12	N
6	,, 31	19·76	560	,, ,,	,,	7·25	57	14	54	12	I
7	Nov. 8	16·23	460	Original.	,,	6·50	46	8	50	10	N
8	,, 8	16·76	475	,,	,,	6·50	46	8	54	12	I*a*
9	,, 9	16·93	480	,,	,,	6·50	48	9	52	11	N
10	,, 30	15·91	451	,,	,,	6·50	68	20	57	14	N
11	,, 30	16·55	469	,,	,,	6·50	68	20	57	14	N
12	Oct. 5	12·35	350	,,	Nil.	6·50	54	12	..	..	N
13	,, 29	15·52	440	,,	,,	7·25	50	10	..	..	N
14	Dec. 18	19·40	550	,,	,,	6·75	54	12	..	..	I

* Ignited with No. 8 detonator.

a Another coal-dust, containing 21·2 per cent. of volatile matter.

10. KOHLEN-CARBONIT.*

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Temperatures. Of the Gallery. Cent.	Temperatures. Of the Coal-dust. Fahr.	Temperatures. Of the Coal-dust. Cent.	Results.
	1894.	Oz.	Grms.		%	Fahr.	Cent.	Fahr.	Cent.	
1	Oct. 18	2·19	62	Original.	Nil.	..	..	..	..	*a*
	1895.									
2	Mar. 20	7·41	210	,,	,,	..	..	..	..	*b*
	1894.									
3	Oct. 18	7·05	200	,,	With coal-dust.	,,	42	5½	50	10	N
4	,, 18	9·03	256	,,	,,	,,	45	7	50	10	N
5	,, 18	10·72	304	,,	,,	,,	45	7	50	10	N
6	,, 18	12·35	350	,,	,,	,,	52	11	50	10	N
7	,, 20	15·70	445	,,	,,	,,	52	11	46	8	N
8	,, 20	10·55	299	,,	,,	2·25	52	11	46	8	N
9	,, 24	15·73	446	,,	,,	2·25	57	14	50	10	N
10	,, 24	15·66	444	,,	,,	6·50	54	12	50	10	N
11	,, 26	15·80	448	,,	,,	7·25	54	12	50	10	N
12	Nov. 29	15·66	444	,,	,,	6·50	73	23	57	14	N
13	,, 29	18·13	514	,,	,,	6·50	81	27	57	14	N
14	,, 29	18·10	513	,,	,,	7·30	84	29	68	20	N
	1895.									
15	Jan. 24	17·46	495	,,	,,	6·50	68	20	61	16	N
16	,, 26	18·13	514	,,	,,	6·75	64	18	54	12	N
17	,, 26	17·46	495	,,	,,	7·25	68	20	50	10	N
18	,, 26	21·38	606	,,	,,	7·25	77	25	57	14	N
	1894.									
19	Oct. 23	12·35	350	,,	Nil.	6·50	52	11	..	..	N
20	,, 23	15·88	450	,,	,,	6·50	52	11	..	..	N
21	Nov. 29	15·77	447	,,	,,	6·50	68	20	..	..	N
	1895.									
22	Mar. 26	16·41	465	,,	,,	6·50	63	17	..	..	N
23	,, 26	17·08	484	,,	,,	7·00	68	20	..	..	N
24	,, 26	21·41	607	,,	,,	7·00	66	19	..	..	N
25	,, 26	21·17	600	,,	,,	7·30	66	19	..	..	N

* Ignited with No. 6 detonator.

a No flame. *b* Very feeble shimmer of light at the first window.

TABLE B.—SECOND SERIES OF EXPERIMENTS.

REFERENCES: I, ignition; N, non-ignition.

11. GELATINE-DYNAMIT.

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Temperatures. Of the Gallery. Cent.	Temperatures. Of the Coal-dust. Fahr.	Temperatures. Of the Coal-dust. Cent.	Results.
	1895.	Oz.	Grms.		%	Fahr.	Cent.	Fahr.	Cent.	
1	Jan. 15	3·84	109	Original.	With coal dust.	Nil.	50	10	46	8	I
2	,, 19	3·67	104	,,	,,	,,	50	10	50	10	I
3	Mar 18	3·53	100	,,	,,	,,	59	15	59	15	I
4	,, 19	3·63	103	,,	,,	,,	43	6	59	15	I
5	,, 19	2·65	75	,,	,,	2·25	50	10	59	15	I
6	April 20	2·65	75	,,	,,	1·60	59	15	59	15	I

12. ROBURIT.

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery.		Temperatures. Of the Coal-dust.		Results.
	1895.	Oz.	Grms.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
1	Jan. 5	10·38	300	Repacked in non-paraffined paper.	With coal-dust.	Nil.	51	12	41	5	I
2	,, 5	9·03	256	,, ,,	,,	,,	50	10	41	5	N
3	,, 5	8·99	255	,, ,,	,,	,,	64	18	41	5	N
4	,, 5	10·76	305	,, ,,	,,	,,	46	8	41	5	I
5	,, 5	7·13	202	,, ,,	,,	2·25	70	21	41	5	I
6	,, 5	5·36	152	,, ,,	,,	2·25	64	18	41	5	I
7	,, 8	5·43	154	,, ,,	Nil.	6·50	63	17	..	..	I
8	,, 8	5·43	154	,, ,,	,,	6·50	61	16	..	..	I
9	,, 8	4·30	122	,, ,,	,,	6·50	61	16	..	..	I

13. WETTER-DYNAMIT.

	1895.	Oz.	Grms.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
1	Jan. 15	14·43	409	Original.	With coal-dust.	Nil.	46	8	46	8	N
2	Mar. 15	14·22	403	,,	,,	,,	59	15	59	15	N
3	,, 26	16·30	462	,,	,,	,,	61	16	59	15	N
4	Jan. 15	10·41	295	,,	,,	2·25	50	10	46	8	N
5	,, 18	12·98	368	,,	,,	2·25	54	12	57	14	I
6	,, 19	10·62	301	,,	,,	2·25	54	12	50	10	N
7	Mar. 18	8·82	250	,,	,,	2·30	64	18	59	15	N
8	,, 18	10·83	307	,,	,,	2·30	64	18	59	15	N
9	,, 18	12·59	357	,,	,,	2·30	70	21	59	15	I
10	,, 26	13·93	395	,,	,,	1·30	63	17	59	15	I
11	Jan. 15	3·60	102	,,	,,	6·50	50	10	46	8	I
12	,, 15	2·54	72	,,	,,	6·50	55	13	46	8	N
13	Mar. 15	2·79	79	,,	,,	6·50	68	20	59	15	I
14	,, 15	2·68	76	,,	Nil.	6·50	68	20	..	..	I

14. WESTFALIT.

	1895.	Oz.	Grms.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
1	Jan. 23	8·47	240	Original.	With coal-dust.	Nil.	57	14	50	10	I
2	,, 23	6·14	174	,,	,,	,,	61	16	54	12	I
3	Mar. 19	7·05	200	,,	,,	,,	57	14	59	15	I
4	,, 19	17·64	500	Repacked in non-paraffined paper.	,,	,,	57	14	59	15	N
5	Jan. 22	19·23	545	,, ,,	,,	2·25	64	18	46	8	N
6	,, 22	23·04	653	,, ,,	,,	2·25	66	19	50	10	N
7	,, 12	15·98	453	,, ,,	,,	3·50	61	16	54	12	N
8	,, 12	15·91	451	,, ,,	,,	3·50	64	18	54	12	N
9	,, 12	15·93	453	,, ,,	,,	4·25	61	16	54	12	N
	1894.										
10	Dec. 31	12·52	355	,, ,,	,,	5·00	54	12	59	15	I
11	,, 31	10·83	307	,, ,,	,,	5·00	59	15	61	16	I
12	,, 31	8·82	250	,, ,,	,,	5·00	63	17	63	17	N
	1895.										
13	Jan. 9	10·55	299	,, ,,	,,	5·00	46	8	45	7	I
14	,, 9	9·10	258	,, ,,	,,	5·00	64	18	61	16	N
	1894.										
15	Dec. 28	9·13	259	,, ,,	,,	6·50	59	15	54	12	I
	1895.										
16	Mar. 15	9·10	258	,, ,,	,,	6·50	68	20	59	15	N
	1894.										
17	Dec. 27	11·40	323	,, ,,	Nil.	6·50	61	16	..	..	I
18	,, 27	10·65	302	,, ,,	,,	6·50	59	15	..	..	I
	1895.										
19	Mar. 12	9·28	263	,, ,,	,,	7·00	68	20	..	..	N
20	,, 12	10·80	306	,, ,,	,,	7·00	68	20	..	..	I
21	,, 12	9·10	258	,, ,,	,,	7·00	66	19	..	..	I
22	,, 12	8·96	254	,, ,,	,,	6·30	70	21	..	..	I

15. DAHMENIT.

No. of Experiment.	Date.	Explosive. Weight.	Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery. Fahr.	Temperatures. Of the Gallery. Cent.	Temperatures. Of the Coal-dust. Fahr.	Temperatures. Of the Coal-dust. Cent.	Results.
	1895.	Oz. Grms.			%					
1	Mar. 6	8·54 242	Original.	With coal-dust.	Nil.	54	12	59	15	N
2	,, 6	12·66 359	,,	,,	,,	54	12	59	15	I
3	,, 6	10·58 300	,,	,,	,,	54	12	59	15	N
4	,, 26	10·23 290	,,	,,	,,	54	12	59	15	I
5	,, 6	16·09 456	Repacked in non-paraffined paper.	,,	2·30	68	20	59	15	N
6	,, 7	16·05 455	,, ,,	,,	2·25	68	20	59	15	N
7	Jan. 11	15·98 453	,, ,,	,,	3·50	61	16	54	12	N
8	,, 11	10·58 300	,, ,,	,,	5·00	59	15	46	8	N
9	,, 11	10·86 308	,, ,,	,,	5·00	57	14	50	10	N
10	,, 11	12·63 358	,, ,,	,,	5·00	59	15	57	14	I
11	,, 11	10·94 310	,, ,,	,,	5·00	59	15	57	14	N
12	Mar. 15	8·99 255	,, ,,	,,	6·60	70	21	59	15	N
13	,, 15	9·06 257	,, ,,	,,	6·70	68	20	59	15	N
14	,, 15	11·01 312	,, ,,	,,	6·70	66	19	59	15	N
15	,, 26	10·58 300	,, ,,	,,	6·90	68	20	59	15	I
16	,, 12	10·83 307	,, ,,	Nil.	7·00	68	20	..	..	I
17	,, 12	9·06 257	,, ,,	,,	7·00	68	20	..	..	N
18	,, 12	9·06 257	,, ,,	,,	7·00	68	20	..	..	I

16. PROGRESSIT.

	1895.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Feb. 28	7·76	220	Original.	Nil.	Nil.	64	18	..	..	*a*
2	,, 28	11·75	333	,,	With coal-dust.	,,	64	18	57	14	I
3	,, 28	9·17	260	,,	,,	,,	64	18	57	14	N
4	,, 28	12·31	349	,,	,,	,,	61	16	59	15	N
5	Mar. 2	12·07	342	,,	,,	,,	64	18	59	15	I
6	,, 8	12·13	344	,,	,,	,,	54	12	59	15	N
7	,, 8	12·91	366	,,	,,	,,	59	15	50	10	I
8	,, 8	12·10	343	,,	,,	2·25	68	20	50	10	I
9	,, 8	8·82	250	,,	,,	2·25	70	21	50	10	N
10	,, 8	10·65	302	,,	,,	2·25	68	20	50	10	I
11	Feb. 28	14·57	413	Repacked in non-paraffined paper.	,,	5·00	66	19	57	14	N
12	,, 26	17·57	498	,, ,,	,,	7·00	66	19	59	15	I
13	,, 26	16·23	460	,, ,,	,,	7·00	66	19	59	15	I
14	Mar. 2	9·56	271	,, ,,	,,	7·00	70	21	59	15	N
15	,, 2	13·44	381	,, ,,	,,	7·00	70	21	59	15	I
16	,, 2	14·18	402	,, ,,	,,	6·20	64	18	59	15	N

a Flame at the first window.

17. DAHMENIT A.*

	1895.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Mar. 4	8·82	250	Original.	Nil.	Nil.	57	14	..	..	*a*
2	Feb. 22	14·18	402	,,	With coal-dust.	,,	59	15	57	14	N
3	April 5	17·71	502	,,	,,	,,	50	10	59	15	N ‡
4	,, 5	17·85	506	,,	,,	2·25	63	17	59	15	N ‡
5	Feb. 22	14·22	403	,,	,,	5·75	72	22	59	15	N
6	April 5	17·75	503	,,	,,	5·00	63	17	59	15	N ‡
7	Feb. 22	15·84	449	,,	,,	7·00	72	22	61	16	N
8	,, 22	20·43	579	Repacked in non-paraffined paper.†	,,	7·20	72	22	59	15	I
9	April 5	17·67	501	Original.	,,	6·30	66	19	59	15	N ‡
10	,, 23	17·85	506	,,	Nil.	6·75	57	14	59	15	N ‡
11	,, 5	17·64	500	,,	,,	6·30	68	20	..	..	N ‡
12	,, 5	19·40	550	Repacked in non-paraffined paper.†	,,	6·30	66	19	..	..	N
13	,, 5	19·83	562	,, ,,	,,	6·30	61	16	..	..	N
14	,, 5	19·83	562	,, ,,	,,	7·00	66	19	..	..	I
15	,, 23	17·64	500	Original.	With coal-dust.	6·75	59	15	59	15	N

a Flame at the first window. * Ignited with No. 7 detonator. † Explosive was repacked, in order to use large quantities. ‡ The cartridges reached to the aperture of the borehole.

TABLE C.—THIRD SERIES OF EXPERIMENTS.

REFERENCES: I, ignition; N, non-ignition.

About ½ ounce (15 grammes) of coal-dust was uniformly distributed within the borehole of the cannon. The explosive was set on the bottom of the borehole, a free space being left, about 7 inches (between 170 and 180 millimetres) long.

18. WESTFALIT.

No. of Experiment.	Date.	Explosive. Weigh.		Explosive. Cartridge Cases.	Coal-dust.	Fire-damp.	Temperatures. Of the Gallery.		Temperatures. Of the Coal-dust.		Results.
	1895.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
1	Jan. 22	15·98	453	Repacked in non-paraffined paper.	With coal-dust.	2·25	68	20	50	10	I
2	,, 22	13·72	389	,, ,,	,,	2·25	72	22	59	15	I
3	April 9	13·90	394	,, ,,	,,	2·20	68	20	59	15	I

19. DAHMENIT.

	1895.	Oz.	Grms.			%	Fahr.	Cent.	Fahr.	Cent.	
4	Mar. 26	14·11	400	Repacked in non-paraffined paper.	With coal-dust.	2·25	68	20	59	15	I
5	,, 26	13·30	377	,, ,,	,,	2·25	66	19	59	15	I

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES' COMMITTEE"* AND UPON MR. WINKHAUS' "EXPERIMENTS WITH EXPLOSIVES."†

Mr. W. J. ORSMAN (Wigan) said that Mr. Winkhaus' paper could not be placed side by side with the *Report* of the Committee of The North of England Institute of Mining and Mechanical Engineers, because all the explosives described in the paper were "made in Germany" and were not in anyway similar (the composition being totally different) with the explosives made in England under practically the same names. With regard to Mr. Winkhaus' conclusions, it was stated that different results had been obtained on different occasions from the different explosives, and the result was attributed to shortness of flame. He (Mr. Orsman) had lately obtained from the different makers samples of each of the explosives mentioned in the paper, and he found in every case where the explosives had been mentioned as not igniting the gas it was really due, not to any apparent goodness of the explosive itself, but to imperfect

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593, and vol. ix., pages 115 and 206.

† *Ibid.*, vol. ix., page 250.

detonation. If those who had followed carefully the composition of explosives would take the trouble to look into the composition of the explosives mentioned as not igniting explosive mixtures of gas, they would find the composition was such as to yield, on detonation, a certain proportion of carbon monoxide, or in other words, incomplete combustion took place, either owing to a deficiency of oxygen or to the detonator not being strong enough to detonate all the explosive. In almost every case where incomplete combustion was obtained, there would be non-ignition of gas, consequently the experiments in the paper were very incomplete, as it was not stated whether each cartridge had been wholly detonated. It was a very ingenious argument, to state that when the explosive did fire the gas it was due to the paraffin on the paper cover, but it was not perfectly correct, for one could easily see that if the ceresin or paraffin did happen to be heated very strongly by the explosive, if there was not an excess of oxygen, no explosion could take place, and as a rule when an explosive was fired they did not get an excess of oxygen. He proposed to show the members a few experiments which would bear out one or two points he spoke of at a previous meeting, and there was also a new point which might be of interest to Mr. Kayll and others with regard to the delay of the ignition of gas. In the *Report*, there were cases mentioned in which delayed ignitions of gas were obtained, $1\frac{1}{2}$ or 2 seconds interval occurring. Another point was the easy combustibility of coal-dust in mixtures of carbon monoxide and air. If carbon monoxide were generated by an explosive in a mine, a very dangerous factor was introduced because coal-dust would readily burn in a mixture of carbon monoxide and air. [Mr. Orsman then made experiments demonstrating how readily coal-dust could be ignited in mixtures of carbon monoxide* and air. Mr. Orsman also illustrated the three distinct phases of an explosion of mixture of coal-gas and air—the quiet burning, the vibration, and the sudden pressure or the detonation—by experiments with a long vertical glass tube. The gases were ignited at the open end of the tube, and the flame travelled steadily downwards to a certain point, where vibrations were set up, and the gases then exploded violently or were extinguished.]

Mr. A. L. Steavenson asked if an explosive when carefully and completely fired was liable to give off carbon monoxide, or only when it was incompletely detonated or blown-out without doing its work?

Mr. Orsman said it depended entirely on the explosive. Some explosives would give off carbon monoxide whether properly or badly

* The carbon monoxide used in these experiments was the product of the detonation of carbonite in a closed bomb.

fired; thus it did not matter how carbonite was fired, it would always yield about 40 per cent. of carbon monoxide.

Mr. A. L. Steavenson said that Mr. Winkhaus' paper was an excellent addition to the valuable information on this subject, which was being gradually stored up in the *Transactions*. He observed in the paper that all the shots were fired without stemming, but as there was a great deal of difference between shots stemmed and unstemmed, he thought the experiments should not be concluded without a series with shots properly stemmed. It was stated in the paper that "the impalpable coal-dust used in the experiments, taken from the sweepings of the screening-apparatus of a bituminous coal-pit, was throughout obtained from the same source. Its uniformity was constantly checked by means of analyses and by comparative shots fired with a given quantity of an explosive whose ignition-limit was known." It was also stated that "the physical properties of the dust (fineness of state of division, etc.) were, as a consequence of its origin, uniform throughout." It was desirable, however, to have some gauge to know what the fineness of the dust really was, for dusts varied very considerably. A useful remark was, "in the presence of gaseous mixtures containing small percentages of fire-damp (say about $2\frac{1}{4}$ per cent. of marsh gas) the safety of the greater number of explosives was found to diminish in a very remarkable degree." Blasting-powder appeared to have been excluded from the experiments, on the ground that it was highly dangerous in all fiery and dusty mines, and should therefore be no longer used in such mines. No doubt they were gradually all coming to that opinion, and although many people say that all the safety-explosives would give a flame and explode gas, they would not do so to the same extent as powder, which was undoubtedly the worst of all explosives. The composition of westfalit differed somewhat from the analysis of the similar explosives used by the Explosives Committee. The experiments with electric detonators were very satisfactory. He thought it had been contended in regard to some tests that the question of the size of the detonator had a good deal to do with the fact of whether ignition of the explosive was caused or not. The question of the paraffined cover was important, for if the workmen had to take off these covers it would considerably mar their effect in use.

Mr. W. C. Blackett said that the various discussions which they had had upon this subject served to strengthen the objection he took at first to the assumption that all the observations of light by the experimenters were due to dangerous flame. To illustrate his meaning, although it

was a little far-fetched, let him take the case of a fire-fly or glow-worm. If a number of these insects had been seen in the experimental apparatus it was quite likely that the observers would have said that they had seen sparks or even small flames, although what they really had seen would be light at a temperature which could not be said to be very hot. There were other lights, reflected lights, phosphorescent lights, and so on, which were no guides to temperature, and temperature was the main thing which the Explosives Committee ought to have observed. Mr. Hedley at the last discussion said that if a detonator was fired in a darkened room, flame could always be seen, and that flame might or might not be able to ignite gas. Now, the *Report* in connexion with detonators did not, he believed, ever use the term flame, it was always the infinitely better and more accurate term "flash," so that it was an innovation now to say that a detonator fired in a darkened room could always be seen to yield flame. The temperature applied (or the so-called flame) must have time and bulk or the gas would not be inflamed. This feature seemed to suggest that the different inflammabilities of coal-gas and pit-gas would be accounted for by the difference in their specific heats, rather than by the difference between their temperatures of ignition. Nothing had been said in the discussion which altered his opinion, that the statements made by the Explosives Committee to the effect that no greater safety was obtained by extra stemming was most misleading. All that could legitimately be claimed by the Explosives Committee was that in their experiments with plastic clay they had been unable to observe any greater safety with extra lengths. The remark as to stemming then only applied to plastic clay, and should not be allowed to apply to other and better forms of stemming. However desirable plastic clay might be as a stemming on account of its incombustibility, it appeared to him to be one of the worst (with the exception, perhaps, of water) for physical reasons. He thought that they had had in the experiments shown by Mr. Orsman a good argument bearing upon stemming. It must be admitted as a fact that, if the explosive had plenty of work to do, there would be less heat. If there had been something used which would have adhered better to the sides of the cannon, it would have given the explosive more work to do, and the extra length of stemming would have reduced the heat, and thereby have afforded greater safety. The experiments of the Explosives Committee did not to his mind so strongly point to condemning extra lengths of stemming as to condemning plastic clay, and he for one would have felt obliged had they retried some of their experiments with other substances, such as seggar-clay borings, which would

have better resisted ejection owing to the greater side-friction. Mr. Hedley on page 221* appeared to refer to something which he (Mr. Blackett) had said at a former discussion, where he threw some doubt on the value of the experiments because the conditions were not those of the mine, referring to the use of the diaphragm. Mr. Hedley said that he (Mr. Blackett) admitted such conditions might exist. That was not so. All he admitted was that they might be approximately produced, but that to do so would be as careless as using an imperfect safety-lamp. Members would perhaps agree with him when he explained that the only conceivable way in which the condition of the diaphragm could be reproduced in the mine would be by carefully bratticing a gallery, thus shutting off all air access and then firing the shot. Mr. Hedley also said that the Explosives Committee did not intend to compare gunpowder with other explosives in the Trauzl blocks. Probably then it was owing to an inadvertence that four experiments with gunpowder had been included in Table I. In the same table, in experiment No. 10, with ammonite, it was a curious fact that although the hole in the leaden block was said to have been driven right through, yet, what one would naturally suppose to be an indefinite cavity, had been accurately measured as 813 cubic centimetres.

Mr. M. Walton Brown said that he would like to draw one or two comparisons between the results given in Mr. Winkhaus' paper and those recorded in the *Report* of the Explosives Committee. The first was with regard to the length of flame which Mr. Winkhaus said did not exceed 6 or 7 inches, but much greater lengths were recorded in the *Report*. The pit-gas from the Schalke colliery could be very readily ignited, while the Hebburn pit-gas was not so readily ignited. In Mr. Winkhaus' paper, the German names of the explosives had been retained so that the difference in composition referred to by Mr. Orsman might not be overlooked. Mr. Steavenson made some remarks with reference to the difficulty of removing the outer cases of the explosives, but this was not so difficult as might at first sight appear, as two paper covers were used on such explosives as westfalit, etc. It occurred to him that perhaps Mr. Kayll or Mr. Hedley might give some further information as to the casing of the explosives used at Hebburn. A special danger arising from coal-dust being left in shot-holes was incidentally mentioned in Mr. Winkhaus' paper; it was stated that if cartridges were placed 6 or 7 inches down a borehole, ignition of the dust-laden atmosphere could be

* *Trans. Fed. Inst.*, vol. ix.

produced if a very small quantity of coal-dust were lying within the borehole in front of the explosive.

Mr. J. L. Hedley (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that in no case were the original covers kept on the explosives in the Hebburn experiments, a brown paper cartridge being made for each explosive. Mr. Blackett raised the point as to how they obtained the measurement of the cavity produced in the Trauzl leaden block by a certain explosive. The explanation was very simple: a small hole was blown into the bottom of the leaden block, it was simply covered up, and the measurements were taken as if the hole had not been made. With reference to the flame or flash of detonators, possibly he had used the word "flame" when "flash" was intended, and he should have been careful to make the distinction. He had sufficiently explained this matter before, and he could only say what they thought they had seen, and they could not help it if other gentlemen did not think they had seen flame. With respect to the stemming, he had before explained that the Explosives Committee agreed to use a certain kind, and the results given were simply comparative; with 1 inch of stemming they got similar results, so far as safety was concerned, as with 8 inches. They did not say that they would get similar results with other sorts of stemming, but the stemming used was that which was approved of by the manufacturers of the explosives and largely used in mines throughout the country. It might or might not be satisfactory, but what they had to prove was whether the stemming recommended was safe or not, and the results were recorded in the *Report*.

The President said that this subject of explosives had occupied much attention lately, but they could not overrate its importance. Legislation was likely to take place very shortly with reference to the question of shot-firing in mines, and therefore the importance of learning as much in anticipation of that legislation would be patent to all, and each member of the Institute should take advantage of the great opportunities which were now afforded them in this direction.

Mr. Winkhaus wrote that Mr. W. J. Orsman asserted in his remarks that the experiments described in his (Mr. Winkhaus's) paper were very incomplete, because it had not been determined whether every cartridge had been fully detonated. To that circumstance, he (Mr. Orsman) attributed the failure in many cases of the various explosives to bring about ignition of the pit-gas. He (Mr. Winkhaus) had frequently noticed incomplete detonation of the explosives, particularly in the case of nitrate-of-ammonium explosives, but he had always regarded such

experiments as failures, and had not recorded them in his paper. Imperfect detonation chiefly occurred when the samples of explosives, through having been long warehoused, had become damp. But whenever with the strongest detonators (No. 8), perfect detonation did not take place, the explosive in question was put aside and fresh samples for further experiments were immediately obtained from neighbouring collieries. The phenomena which accompany incomplete detonation of the explosive could hardly escape the eye of the observer. In such cases one finds on the floor of the gallery, and particularly in the bore-hole of the cannon, remnants of the explosive more or less abundant. Now, as all the shots were fired in his (Mr. Winkhaus') presence, and as, moreover, by scraping out the bore-hole and examining the floor of the gallery, he was able to ascertain unmistakably whether remnants of the explosive were to be found or not, he regarded it as quite out of the question that a failure to explode could have escaped his attention. Nor did he (Mr. Winkhaus) admit that, in the case of a single one of the experiments recorded in his paper, there could have been incomplete detonation of a cartridge. The liberation of carbon monoxide had attracted his (Mr. Winkhaus') attention when investigating the after-damp produced by the explosives. The experiments relating to their influence on the explosibility of coal-dust had been already begun, but were not yet completed. With regard to Mr. A. L. Steavenson's suggestion that it would be desirable to have some standard of the fineness of the dust used in the experiments, he (Mr. Winkhaus) would add that this was the impalpable (flying) or upper dust (an expression not rendered in the translation) from a screening-apparatus. By this he (Mr. Winkhaus) meant the dust thrown up by the shaking of the screens, at first it remained suspended in the air and subsequently was deposited in the vicinity of the screen on the floor, the timbering and such like. This was an extremely fine meal-like dust, whose physical properties should correspond exactly to those of the dust in the pit, on the sides, roof, timbering, etc. The fineness could not be measured. On shaking it through a No. 90 sieve (8,100 meshes per square inch) no residue was left on the sieve. The experiments with stemming would be commenced very shortly, as stated in his paper.

DISCUSSION ON MR. W. O. WOOD'S PAPER ON "THE MURTON COAL-WASHER.*

The PRESIDENT said that the apparatus erected by Mr. W. O. Wood was a very simple and complete coal-washer. The chief novelty was that the water travelled in the opposite direction to the coal.

Mr. W. C. BLACKETT asked if the cubical capacity of the settling-tanks and the amount of coal washed per day could be stated?

Mr. W. O. WOOD said that the four settling-tanks had practically a total capacity of 1,000 cubic feet for 400 tons of coal washed per day. The sulphur, as a rule, decreased in proportion as the amount of ash decreased. If a coke contained 7 or 8 per cent. of ash, it might contain 1·50 per cent. of sulphur; if that ash were reduced to 5 per cent., the sulphur would be reduced in similar proportion, but in the long run, however low they got the ash, there still remained a fixed quantity of sulphur chemically combined with the coal which it was impossible for any operation of washing to reduce. The ash was mentioned in the paper as being 5·39, but since then the ash had been reduced by nearly 1 per cent., and it was accompanied by a decrease of sulphur of about 0·2 per cent.

Mr. A. L. STEAVENSON said that when in Germany some years ago he saw a coal-washer which did its work excellently—about 500 tons per day—but the cost was £10,000. No doubt the Murton washer and other washers in this country would do the same work equally well for £300 or £400.

The PRESIDENT said that a large proportion of the cost often attributed to a coal-washer was due to other portions of a complete plant. The cost of the Lührig washing-plant at Evenwood colliery was often referred to as enormous, but it included a great amount of plant unconnected with the washing of the coal.

Mr. THOMAS BELL (H.M. Inspector of Mines, Durham) said that the large amount of money expended at Evenwood was not for the washer alone, but included appliances for screening, cleaning, crushing, draining, and storage of the coal afterwards.

Mr. W. C. BLACKETT said that, as a matter of fact, if the Lührig washer alone were compared with other washers it would be found to be no more expensive. It was not fair to take the cost of a large plant and compare it with the cost of a washer. He had had an experience of a washing-

* *Trans. Fed. Inst.*, vol. ix., page 42.

plant, the plan of which would have been applicable to most washers, and he sent out the plans adapted to the washers of several different manufacturers, requesting prices for their particular washers, and out of three or four tenders the Lührig was the cheapest. He might add that the Murton washer was not then invented. The tenders included the cost of the whole of the machinery connected with the washer, and designed to work with it.

Mr. W. O. Wood said that the Murton washer was designed, owing to the excessive cost of other washing-plants.

Mr. J. M. Liddell said that the principle of carrying the water in an opposite direction to the coal washed was largely used in (frue-vanners) gold-washing. The chief difference was that the apparatus had in addition an oscillating motion sideways, so as to secure more perfect separation of minerals, and did not require ripple-bars.

DISCUSSION ON DR. R. BRUNCK'S PAPER ON "THE BRUNCK COKE-OVEN AND SYSTEM FOR THE RECOVERY OF BYE-PRODUCTS,"* AND MR. JOHN H. DARBY'S PAPER ON "THE SEMET-SOLVAY COKE-OVEN."†

Mr. W. C. Blackett said that since the last meeting he had had occasion to peruse some figures in connexion with a proposal to erect Semet-Solvay coke-ovens at an English colliery. Being dubious as to the facts, he took the basis figures used for the Semet-Solvay coke-ovens and applied them to a plant of coke-ovens, such as he imagined would be placed in the category of "despised beehives," and he discovered that where the Semet-Solvay would give 70 per cent. profit the beehive coke-ovens would give 60 per cent. He need not remark that these ovens had never made such a profit, but on paper they were able to do so, and this without considering the value of waste gases firing boilers.

Mr. B. Dodd (Durham) said that in the two papers under discussion much importance was attached to the thick middle walls of the ovens, which the writers state render the ovens very easy to repair; while at the same time they tell us they have had little or no experience with regard to repairs, so they are hardly in a position to speak as to the ease with which these can be made. He (Mr. Dodd) thought, from the construction

* *Trans. Fed. Inst.*, vol. ix., page 47. † *Ibid.*, vol. ix., page 54.

of the ovens, that before the middle walls could be repaired, the inside lining must be removed, and this would entail great labour and expense. In Simon-Carvès ovens, walls of moderate thickness have been found sufficient for all reasonable requirements. At Bearpark cokeyard, a 4 tons locomotive engine and a train of coal-tubs weighing 25 tons have been run directly over the tops of the ovens without doing harm to the arches or side walls of the ovens. The thick walls are said to act as heat-receivers, taking up and giving out heat as the coking proceeds. If this be so, the temperature of these walls will rise and fall, thus causing expansion and contraction of the brickwork, with serious opening of the joints of the same. In Simon-Carvès ovens, a uniform heat is maintained in the flues, as the ovens are loaded alternately, and as long as there is volatile matter to be driven off, the temperature in the ovens does not rise above the boiling-point of the distillate, the heat passed being in volume or intensity as is required and producing as little expansion and contraction of the brickwork as possible. In considering plants for the manufacture of coke, and for the extraction of bye-products, he (Mr. Dodd) might point out that the oven was only one portion of the plant, and perhaps the least important part. The cost of the plant and the speed and economy of working depended upon the power of the condensing-plant; the speed of burning and the total cost being governed by the quantity of coal carbonized more than by the number of ovens; the loss through minor stoppages and the cost of working would be greater the more rapidly the ovens are drawn. In the case of rapidly-drawn ovens, larger hoppers for the storage of coal are required, and also increased siding and waggon accommodation, and owing to the limited bench-area the coke has to be more rapidly removed, entailing increased Sunday and holiday labour, beside the increased useless expenditure of labour in stocking coals and coke, as compared with slower working ovens; in cases where the whole of a colliery's output of coals is coked, this becomes a very serious matter. In the Bearpark coke-ovens, coals have been tested from nearly all parts of the globe and have been found to vary very greatly in the coke and bye-products produced, and in the time required for carbonization when treated in an exactly similar manner—some coals coking from ten to twelve hours sooner than a similar quantity of coals from other localities. Many engineers attach too much importance to the ovens and too little to the nature of the substance put into them; looking upon coal as if it were inorganic matter instead of what it really was, a highly complex organic compound. He was of opinion that a little thought would show that in these bye-products recovery-plants, they were really treating the preserved and

fossilized vegetable growths of the Coal-measures, with the object of obtaining from them their colours and essences, and their medicinal properties. And he thought that, when they considered the vast area of country over which the great forests of the Carboniferous time extended, they would expect to find great variation in the nature of the plant life; that grown on the low lands near the sea-coast differing considerably from the vegetation of the inland and more elevated districts. The colours with which coal-tar dyes were competing, and which were being driven out of the market, were the organic colours which are produced by certain existing forms of vegetable life, such as: aloes from India, alkanet from the Mediterranean, arnatto from Mexico and Brazil, barwood from Africa, camwood from Africa, sanderswood from Africa, Brazilwood from Brazil, Chinese greens from China, ericine from Europe, lac from India, madder from Asia and Central Europe, munyeet from India, orchella from America, Canaries, and Africa, cudbear from Europe, litmus from Europe, quercitron from North America, safflower from Europe and India, woad from Europe. In obtaining these colours from the vegetation of the present time, they extract them from the plants which yield them the most readily and cheaply. No doubt all plants contain colouring-matter, but one would not expect to extract colours from vegetable matter taken indiscriminately, with commercial success, and for this reason they are imported from foreign countries. In dealing with the plant life of a bygone age the same discretion should be used, and colours extracted from those coals which contain the fossilized remains of the plants which produced the colour molecules. The same difference of organic growth which gave rise to the variation in the colours of the plants will affect the nature of their carbonized remains, and produce different cokes in like manner as the different woods produce different charcoals, such as that from box and willow. With regard to the value of retort coke in the blast-furnace, he (Mr. Dodd) was not a blast-furnace manager, but he had attended several meetings of the Iron and Steel Institute, and carefully studied their *Transactions*. He thought that any one who had done so would be inclined to allow that in Cleveland there were several of the most eminent and scientific ironmasters in the world, and that they were also keen business men who knew the value of what they used, Yorkshiremen being amongst Englishmen proverbial for their business capabilities. Well, during the last ten years, these ironmasters, who hold a foremost position amongst metallurgists and business men, had used in their furnaces 77 per cent. of coke made in Simon-Carvès ovens, and had paid prices as high

as those paid for beehive coke during the same period, and no doubt had found it to their advantage to do so. Although the coke made in the Bearpark Simon-Carvès ovens had given satisfactory results, it did not follow that equal success would attend all plants of that description. There are instances where large amounts have been expended over similar plants, which have not proved altogether successful, chiefly through the nature of the coal used.

Mr. A. L. STEAVENSON said he would like to ask if the Simon-Carvès coke could be sold for blast-furnace purposes at the higher price and as freely as common coke?

Mr. DODD said that was so.

Mr. A. L. STEAVENSON—And did the yield of coke correspond to anything like 75 or 80 per cent. of the coal?

Mr. DODD—About 78 per cent.

Mr. W. C. BLACKETT said that while retort coke was perhaps known to be dense, yet density was not all they had to deal with, and what was wanted was not closeness of the cells to one another, which formed density, but hardness of the walls of the cells to bear the burden. In blast furnaces where retort coke was being used, were they as high throughout as the highest furnace using beehive coke?

Mr. DODD said the retort coke would carry any amount of weight; if anything it was perhaps too dense, and gave better results in smaller pieces. It had been used in both high and low furnaces.

The discussion was then closed.

DISCUSSION UPON MR. B. H. THWAITES' PAPER ON "ENGINEERING HELIOGRAPHY."*

Mr. B. H. THWAITES wrote that the developing bath consists of a flat vessel slightly larger than the print, and some $2\frac{1}{2}$ inches deep, made of wood, and treated with a varnish applied to a thickness of $\frac{1}{8}$ inch—the varnish being composed of $\frac{1}{2}$ lb. of brown resin and 2 ounces of beeswax. The Thwaite developing bath (Fig. 10, Plate III.) is of a vertical form, so that when the prints are immersed the redundant and unacted on iron salts are deposited at the bottom. For acid solutions, the bath should be lined with vulcanite, enamelled iron, or be made of earthenware.

The meeting then terminated.

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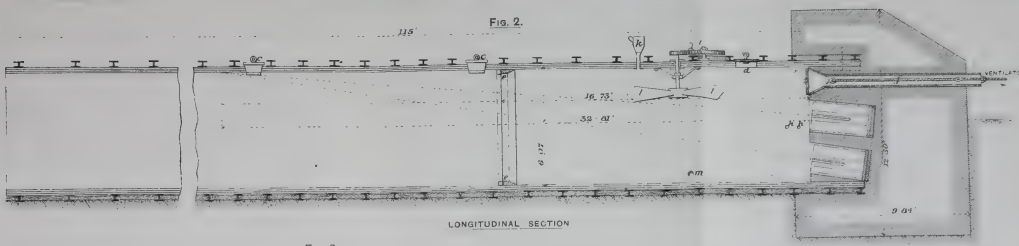
* *Trans. Fed. Inst.*, vol. ix., page 69.

Fig. 2.

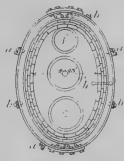


LONGITUDINAL SECTION

Fig. 7.

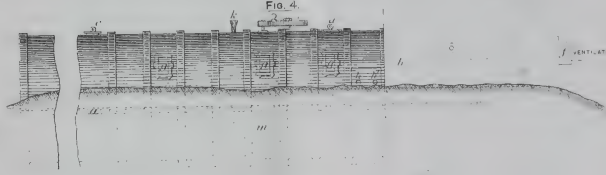
Fig. 8.

Fig. 3.



CROSS SECTION

Fig. 4.



SIDE ELEVATION

Fig. 5.

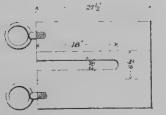
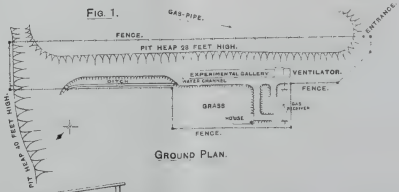


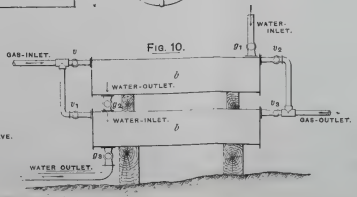
Fig. 6.

Fig. 1.



GROUND PLAN.

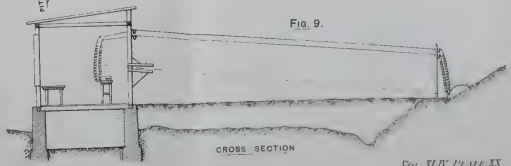
Fig. 10.



REFERENCES.

b b_1 — GAS-INLET VALVES.
b_2 b_3 — GAS-OUTLET VALVES.
g_1 — WATER-INLET VALVE.
g_2 — INTERMEDIATE WATER-VALVE.
g_3 — WATER-OUTLET VALVE.

Fig. 9.



CROSS SECTION

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

NATIVE BISMUTH IN WESTERN SUMATRA.

Het Voorkomen van Bismuth op het Schiereiland Samosir [*Tobameer*]. *By* N. Wing Easton. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1894, *vol. xxiii. technisch-en administratief Gedeelte, pages* 84-93, *and plate I.*

The announcement of the occurrence of native bismuth on the peninsula of Samosir attracted considerable attention in 1892. The metal is extracted by washing from a loamy sand, which fills up cavities, mostly closed, in a tufaceous sandstone occurring along the banks of a stream. There are indications of the natives having at one time worked the deposit. The sand of the actual river-bed yields only occasional lumps of bismuth, and its general mode of occurrence throws little light on the primary origin of the metal.

The aspect of the bismuth and its crystalline fracture suggest a previously molten condition. There are no traces of the minerals usually associated with that metal. It appears to be a secondary deposit consisting of nests of metal very dispersedly distributed. The cavities containing these nests are intimately connected with the structure of the tufaceous sandstone, and with the occurrence in it of pebbles harder than the rock itself.

Search was made for other likely localities in river-valleys, a search rendered in some cases nugatory by the floods consequent on heavy rain. The rivers carry bismuth where the tufaceous sandstone crops out, and by Hoetana Bolon the metal occurs in a pumice-bearing tuff which forms the walls of the ravine; but, on the whole, the results may be regarded as negative, and the important occurrences as restricted to the tufaceous sandstone-area lying between Si Déak and Sipakok. At present there can be no question of sale or export.

The hypothesis of the origin of the bismuth is much as follows. A liparite-lava in the course of eruption came into contact with metalliferous, particularly bismuth-bearing lodes, and the bismuth, on account of its easy fusibility, was separated from its associated minerals and carried along in the liparite-crust. As the eruption took place under water, the liparite was of a slaggy, pumiceous character, and the molten metal collected, therefore, in the cavities of the porous mass. This mass offered practically no resistance to erosion, and helped to build up the subsequently formed tufaceous sandstone in which the metal now occurs.

A geological map of Samosir Peninsula and the Toba district is given in the other volume (Wetenschappelijk Gedeelte) of the *Jaarboek* for the same year (page 99). O. S. E.

THE FRIEDEBERG APPARATUS FOR BURNING COAL-DUST.

Die Kohlenstaubfeuerung "Patente Friedeberg." By DR. B. KOSMAN. *Berg-und Huettenmœnnische Zeitung*, 1894, *vol. liii., pages* 371-374, *and five figures.*

The apparatus consists of a vertical blast-pipe closed at the top and provided on one side with two circular openings. The vertical blast-pipe is covered with a revolving casing, fitted with pipes, so that when the apparatus is in use the pipes coincide with the openings in the blast-pipe. The blast is cut off and the feed stopped to the furnace by the whole apparatus being revolved around the blast-pipe.

The apparatus consists of a vertical hopper to receive the coal-dust, terminating in a box provided with openings at the bottom. Nozzles are arranged so that the blast moves and blows the coal-dust towards the delivery-pipe. Any pieces of coal in the dust fall to the bottom of the delivery-pipe, and may be removed by means of a movable slide.

Below the boxes and hopper is a horizontal blast-pipe, connected at one end with the vertical blast-pipe, and terminating in a nozzle opening into the base of the conical chamber attached to the front of the boiler-furnace. The upper and lower blast-pipes are fitted with throttle-valves by which the air-pressure may be regulated. The conical chamber attached to the boiler-furnace is fitted with a solid core, which secures the intimate and continuous mixture of the air and coal-dust fed into the furnace. The blast may be supplied by a Root or other blower, and requires from $\frac{1}{2}$ to $1\frac{1}{2}$ horse-power according to the size of the apparatus and the quantity of coal-dust fed into the furnace.

The maximum size of coal-dust should not exceed that passing through a 0·1 inch mesh screen; the best results being obtained with coal passed through a 0·04 inch mesh screen.

A Friedeberg apparatus has been applied to a Cornish boiler with a heating surface of 900 square feet, and supplies steam at a pressure of 90 lbs. per square inch to a 50 horse-power engine; the consumption of English small coal being 5,600 lbs. per day. The consumption of fuel before using the apparatus was about 6,900 lbs. per day.

Another Friedeberg furnace was applied to a tubular boiler supplying steam at a pressure of 105 lbs. per square inch to a 12 horse-power engine, the consumption of coal-dust being about 750 lbs. per 24 hours. M. W. B.

THE SOUTHERN LIMIT OF THE COAL-FIELD OF NORTHERN FRANCE.

Considérations sur la Limite Sud du Bassin Houiller du Nord de la France. By GUSTAVE F. DOLLFUS. *Annales de la Société Géologique du Nord*, 1893, *vol. xxi., pages* 332-342.

Recent work and newly-discovered facts all tend to confirm the mapping (by the French Geological Survey) of the anticlinal which forms the southern boundary of the coal-basin of the departments of the Nord and the Pas de Calais.

A boring at Bouchain, after passing through 24 feet of Pleistocene deposits and 252 of Cretaceous, struck Lower Devonian sandstones and slates. These Devonian strata dip very steeply to the south (60 or 80 degs.) Several accidents having taken place, the boring was stopped at 607 feet.

Another boring, at Noyelles-sur-Selles, $2\frac{3}{4}$ miles east of Bouchain, proved that beneath 10 feet of superficial deposits only 128 feet of Cretaceous intervened before the Devonian was reached. The sandstones and slates have much the same

character and dip as in the other boring. In October, 1893, the boring was still being carried on below 610 feet, but the expectation of the engineers, that they would strike a mass of Carboniferous Limestone and Coal-measures nipped in the great southern fault, had not been fulfilled. The levels of the Palæozoic rocks hereabouts agree exactly with the contours predicted by Mr. Marcel Bertrand.

O. S. E.

THE EXTENSION OF THE WURM COAL-FIELD.

Ein neues Steinkohlengebiet. By FRANZ BÜTTGENBACH. *Berg-und Huettenmænnische Zeitung*, 1894, *vol. liii., pages* 361-364, *with figures in the text.*

Workings for coal were begun in the Wurm basin in 1113, and mining industry has gradually and uninterruptedly developed in that district up to the present day. The boundaries of the coal-field westward of the great Feldbiss fault, which appears to strike north-west and south-east, were determined as far back as the sixteenth century, and up to 1846 that fault was regarded as the eastern limit of the coal-field. But certain deep borings put down about the above-mentioned year proved that the Coal-measures extend east of the fault, whose downthrow amounts to several hundreds of feet. And while the seams west of the Feldbiss fault were of meagre anthracitic coal, those east of it (worked near Merkstein and Höngen) were of open-burning bituminous coal: their stratigraphical identity has, however, been established, and another series of seams has been found at a higher horizon, seams which are missing west of the Feldbiss fault. In that westerly area, the measures were folded into synclinals and anticlinals, whose southern limbs were all but perpendicular, while the northern limbs had a comparatively gentle dip of 8 to 12 degs. The seams west of the Feldbiss fault have been long worked in the parish of Kirchrath, on the Dutch side of the frontier, and until recent years it was not thought that the coal-formation extended much west of that locality. But in 1870-79, 29 boreholes put down along the line of the Anstel Valley (Holland) touched the coal below a thick covering of drift, Tertiary beds, and Cretaceous. The Carboniferous measures were reached at depths varying between 131 and 656 feet, the coal-seams at depths between 164 and 755 feet, and the thickness of the latter varied between 12 and 60 inches. The Government of the Netherlands thereupon granted about a dozen mining concessions, but these fell through in 1892, and a new company, largely financed and managed by German capitalists, has now taken over some of the concessions, and has put down a shaft at Heerlen (Orange-Nassau). This place is in the centre of the new extension of the coal-field, and lies 5 miles north-west of Kirchrath, which used to be considered the extreme westerly limit. It is inferred that the lie of the seams will here more nearly approach the horizontal than they do in the south-east portion of the coal-field (*e.g.*, at Höngen, where the measures are folded into zig-zags), and the coal so far proved is bituminous. The author proposes to call this new extension, which covers an area of 29,652 acres, the "Limburg coal-basin," and remarks that its industrial importance is fully equal to that of the whole of the Wurm coal-basin so far known. But there is reason to believe that still another and vaster extension of the coal-field will shortly be revealed: borings near Hückelhoven, 15 miles north of Herzogenrath, have proved the existence of Coal-measures, and would thus enlarge the total area of the Wurm basin to 840 square kilometres (207,564 acres).

O. S. E.

COAL-FIELDS, DIAMOND MINES, ETC., IN DUTCH BORNEO.

Topografische, geologische, mineralogische en mijnbouwkundige Beschrijving van een gedeelte der Afdeeling Martapoera. By J. A. Hooze. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1893, *vol. xxii., pages* 1-431, *with figures in the text, eleven maps and six plates of sections.**

The district of Martapoera is in the Southern and Eastern administrative division of Dutch Borneo. It is bounded on the north by the Riam Kiwa river, which, after joining the Riam Kanan, becomes the Martapoera river. On the south it is shut in by the Bobaris and Meratoes mountains, while westward it stretches to the Java Sea. The district covers an area of 864,850 acres, and the population, almost entirely native (with a very small sprinkling of Chinese), numbers 90,000. Along the coast, and in the lower basins of the great rivers, the country is low-lying and swampy, but it rises inland in hills stretching away to the foot of the Bobaris mountains: between these and the Meratoes massif hilly country alternates with high ranges.

Regarding the Bobaris and Meratoes mountains and the intervening area as one massif, this is found to consist very largely of crystalline schists (quartz-, mica-, hornblende-, actinolite-, chlorite-schists, etc.), of serpentines and gabbros, while diabases crop out in dykes and bosses and sheets. Against this massif rest sedimentaries of pre-Tertiary age, covering all the country between the serpentine boundary-ridge of Bobaris and the hills of Tertiary coal-bearing sandstone. These pre-Tertiaries are mainly fossiliferous sandstones and conglomerates alternating with bands of black marl-slate and red, white, and grey limestone. Red and light-grey porphyrites intrude among these in dykes and bosses. Unconformably upon the pre-Tertiary rocks lie the quartzitic sandstones, and the claystones with bituminous coal of Eocene age, constituting regular ranges of low hills. Above the coal-formation come a series of marls, and then the Nummulitic Limestone: the thickness of the latter averages 7 feet and never exceeds 33. The Eocene is very extensively capped by drift and alluvial deposits. The drift containing diamonds stretches away north of the Maloeka river, along the north-western flank of the Eocene coal-formation, but no diamonds are found in the drift south of the Maloeka nor in the Tabanio river-basin. At some localities the drift rises to a height of more than 197 feet above sea-level. Pliocene strata with brown coals occur north of Martaraman, about 7 miles away from the hills of Eocene coal-bearing sandstone, and at Seboehoer.

It may be noted that the sudden bending in some places of the Eocene coal-bearing sandstones is due to the presence of sheets or bosses of augite-andesite. The pre-Tertiary sedimentaries almost certainly belong to the Upper Cretaceous, and include two distinct groups: the older shales, and the younger sandstones, conglomerates, limestones, marls, etc.

The Eocene formation is capable of subdivision into three groups: (*a*) Lower or Sandstone Group, with bituminous coal-beds; (*b*) Middle or Marl Group; (*c*) Upper or Limestone Group. The Bornean East Coast coals of Tertiary age may be classified according to their combined water as follows:—Coals with more than 20 per cent. of water, Pliocene; with from 15 to 20 per cent., Upper Miocene; with from 9 to 15 per cent., Lower Miocene; with from 3 to 7 per cent., Eocene.

The lithological characters, the fauna and flora of group *a* are described, and then follows a minute stratigraphical description of the principal coal-fields. These are (1) the Pengaron coal-field; (2) the Soengei Raja-Assahan coal-field; (3) the coal-fields between the Takoeti and the Riam Kanan river, including the

* *Trans. Fed. Inst.*, vol. iii., page 354, Plate XXI.

Djalamadi-Djabok coal-field; and (4) the coal-fields between the Riam Kanan and the Banjoe Irang river, and between the Banjoe Irang river and the Java Sea.

The younger Tertiary formations with brown coal occupy a comparatively small portion of the area under consideration. Analyses are given of eleven specimens of brown coal from the Assem-Assem river basin, the ash averaging 1·60, sulphur 1·03, water 22·6, and coke 45 per cent.; the ash of one of these was found to contain gold. Good briquettes can be made from the brown coals.

With regard to the bituminous coals, the Pengaron is a good coking variety, and averages, as to calorific effect, about 88, taking Newcastle coal as 100. Pyrites occurs very generally in it and in the Assahan coal, but in a state of rather minute division. Spontaneous combustion has never been known to take place with Martapoera coals, although in the Pengaron coal-field, for example, the small has lain stacked for years at a time. Fires have frequently broken out in the workings at Assahan, but are attributable to other causes. A very essential constituent of the Eocene coals of Borneo is resin, which is seen in nearly every lump of coal. A description is given of the methods of working, together with statistics of annual production, of the Orange-Nassau mine (first workings opened in 1848) at Pengaron, of the Assahan coal-mine, of the Julia Hermina mine at Kalangan, and of the Delft mine. The probable extension of the coal-fields is also discussed.

The diamantiferous sands and gravels occur along the valleys and in the river-beds of the area marked out by the Riam Kiwa, Riam Kanan, and Banjoe Irang rivers, and it is considered that the diamonds are derived from veins and lodes in the crystalline schists, more especially in the upper river-basins of the Riam Kiwa and Riam Kanan. These veins south of that region become less and less diamantiferous, and at the point where the gold diggings begin the diamonds are wanting altogether. The general occurrence of the diamonds and their physical properties are described, as also the methods of digging and washing the gravels. This section is accompanied by a table of the diamond claims in the Tanah Laut district, and tables of the finds in the Liang Anggang and Bentok diamond-fields. There are diamond-cutting works in Martapoera. An east-and-west line drawn across the Kobbok Hills, along the Seloeang river where the coal-bearing ridges slope away beneath the Quaternary deposits, forms the boundary betwixt the gold and the diamond-fields. The alluvial gold is supposed to be derived, not alone from veins and lodes in the crystalline schists, but from the contact-zones of these with (mainly) serpentine and porphyrite, and from the main mass of the schists themselves. The high-level auriferous deposits are extremely irregular in thickness and extent, but those at lower levels are more regular; the average thickness of the actual band of gold-stuff is 1 foot. The deposits are worked by pits and in open diggings known as *parits*. Tables are given of the chief gold-diggings in the Tanah Laut district and their production. The average richness of the diggings along the valley-sides is 1 carat of gold per square metre and ½ carat per cubic metre of the total mass of material. By the Chinese method of working the mean daily production per head is 4½ carats of gold. The richest *parits* are the Rangga, Rinaat, and Soengei Idjau. These, together with several other diggings, are fully described, and their productiveness is compared with that of other areas.

Platinum occurs in association with the gold and with the diamonds, and is apparently derived from the contact-zone of the serpentines with the crystalline schists. The results of the analyses of eight specimens show that the percentage of platinum in the ore varies between 57·13 and 82·60, of gold between 0 and 9·73, of iron between 5·45 and 10·67, and of copper between 0·13 and 0·73.

Iron (hæmatite) and manganese ores are found in several localities, but at present there is no likelihood of their being worked. O. S. E.

THE ORIGIN OF THE COPPER ORES IN THE TUSCAN SERPENTINE.

Die Kupfererzlagerstätten der Serpentingesteine Toscanas und deren Bildung durch Differentiations-processe in basischen Eruptivmagmen. *By* B. Lotti. *Zeitschrift für praktische Geologie*, 1894, *pages* 18-19.

In Tuscany, under the heading "serpentine" or "ophiolite" are included (1) serpentine proper with its parent-rock lherzolite; (2) gabbro or euphotide, and (3) diabase. These are all of eruptive origin and of Eocene age; they occur in close association one with the other, and always preserve the same relative position, the diabase being on the top, the gabbro below it, and the serpentine and the lherzolite lowest of all. Moreover, the gabbro is seen in places to cut through the serpentine-rock, and the diabase cuts through both, wherefore the author infers that these rocks are the product of two closely successive eruptions.

The commonest ores are iron and copper sulphides; blende and galena seldom occur. Magnetite, as in the Isle of Elba, is common enough, but not in workable quantities.

The copper ores occur chiefly in the gabbro, dispersed in small particles through the mass of the unaltered rock, or forming lodes in its fissures. More frequently they are found in spherical masses, of diameter varying from a few inches to 3 or 4 feet, in a steatitic matrix, which is the decomposition-product of the gabbro.

In accordance with Prof. Vogt's views on the differentiation of eruptive magmas, the author believes that these spherical masses were formed in the process of differentiation of the original magma, in the same way as basic complexes separate out from acid rock-magmas. To the same cause, rather than to the determining influence of specific gravity, he attributes the accumulation of ores in the contact-zone, that is, in the gabbro lying between the serpentine and the diabase. So far from the decomposition of the gabbro having induced the concretion of the spherical masses, it is probably those spherical masses which have, where present, hastened the decomposition of the gabbro. O. S. E.

THE COPPER MINES OF THE PAMPA CENTRAL.

Viaje à la Pampa Central. *By* J. B. Ambrosetti. *Boletin del Instituto Geográfico Argentino*, *vol. xiv.*, *pages* 342-353. *Buenos Aires.*

The mines are situated thirteen miles south of the Sierra de Lihué-Calel, and belong to the *Sociedad del Mineral de la Pampa.* The ore-deposits were discovered by Mr. Tomás Bovadilla, who came thither from Chile, on the faith of an old parchment of the Jesuit Fathers, describing their itinerary from Valdivia to Paraguay. Much of the copper ore so far extracted had been sent experimentally to England. The surrounding country is a desert, covered with scrub, and the nearest water-supply is from a well sunk at Peña Verde, 3¼ miles south of the mines. This yields slightly brackish but drinkable water. Rain-water is stored in a pit of the Dos Chilenos mine.

The eighteen mines which have been started are worked by means of shafts, out of which the ore is hoisted with the help of hand-windlasses and in adits following the course of the veins. From the adits the ore is laboriously brought out in leathern bags on the shoulders of workmen known as *Apires.* In one working-day a good miner is reckoned to drill and fire with dynamite six holes 8 to 12 inches long. Most of the veins are capped by a ferruginous layer, which serves as roof. Thus, at the Flor de la Pampa mine, the cupriferous vein, 10 feet thick, is encased by ferruginous rock, whose contact-surfaces are perfectly smooth, and allow of the

ore being detached without the slightest difficulty. The district is one of plutonic and metamorphic rocks. In the north crystalline mica-schists occur, which it is suggested are the result of the metamorphism of granite by the intrusion of huge masses of quartz. The granite graduates into aplite and greisen. There are also quartzites cleaving vertically, sanidine-rhyolites, and highly garnetiferous eclogites. Copper silicate is disseminated through the quartzite in impregnations, encrustations, and veinlets, accompanied by specular iron ore. Copper also occurs in the form of auriferous and argentiferous oxides and sulphides. Assays made of ores taken from five mines show percentages of metallic copper varying from 3·92 to 7·40 (Dos Chilenos mine) and of silver varying from 0·0015 to 0·0095 (Flor de la Pampa mine). The complete analysis of a very rich sample from the Elisa mine gave the following result :—Copper (as oxide and sulphide), 36·33 per cent. ; silver, 0·0102 per cent. ; and gold, 0·0010 per cent. Mr. Franchy's theory of the genesis of the Lihué Calel copper silicate is that the copper originally existed in the form of pyrites. By decomposition of the portions nearest the surface, the pyrites was oxidized to soluble sulphates. The sulphates in solution entered into reaction with the lime-silicates contained in the felspars of the adjacent rocks, producing silicate of copper, which was then deposited in the form in which we now see it. It may therefore be predicted that, as the workings are pushed deeper down, copper sulphides will be struck ; and, in fact, this prediction has already been verified at the Dos Chilenos mine, where there is a shaft 115 feet deep. Samples taken from 92 feet down were rich in erubescite (bornite). O. S. E.

THE DIAMOND-FIELDS OF LANDAK (WESTERN BORNEO).

Geologisch-mijnbouwkundige Opneming van een Gedeelte der Westerafdeeling van Borneo. Verslag No. 11. *Het diamantvoorkomen in Landak.* ANON. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië.* 1894, *vol. xxiii.* (*technisch-en administratief Gedeelte*), *pages* 94-130, *and plate II.*

A topographical description is given of the district, which is elucidated by a map of the Landak river and its tributaries. The rapids, numerous in all the streams except the Behe, constitute a great obstacle to transport. Thus, to take one example, along barely 33 miles of river there are no less than seven portages.

The diamonds occur in lenticular quartz-gravel deposits called *areng*, of very variable thickness (4 inches to 8 feet); but the thickness appears to have no connexion whatever with the richness of the deposit in diamonds. The quartz-gravels lie in most instances directly upon rock in place ; they have often, above or below, a thin hard layer of brown iron ore, and lumps of ferruginous conglomerate are often dispersed about in them. Flakes of mica, magnetite, and pyrites are abundant. Very hard pebbles of various colours, which the Malays call *leboer*, the author suspects to be corundum : in association with these diamonds always occur. The author describes the *leboer* under four groups, and calls attention to a similar occurrence in the Brazilian diamond-fields.

The whole aspect of the diamantiferous deposits suggests that they were laid down by the Landak river in times when it flowed at a far higher level than now ; and the fact that diamonds have been hitherto found only at a short distance from this river, and not along its tributaries, leads one to infer that the matrix-rock should be sought in the upper Landak basin itself.

The rocks of the country are mainly soft, yellow-brown sandstones, interbedded with thinner argillaceous layers. Hard bands of a more quartzitic or siliceous character are seldom met with. The strata of this so-called "Behe complex" are

much folded into anticlinals and synclinals, and abrupt changes of dip are frequent. Above these lies unconformably in thick beds a hard greyish-green or brown sandstone, it tops many of the hills, and forms almost exclusively the reefs which make the large stream-rapids. This the author calls the Riam (Malay for "rapids") Sandstone.

Above Sikip there is a change in the geological features; granite crops up in the rapids, and this, farther up still, gives place to basalt. The basalt is apparently older than the diamantiferous drift; while contrariwise, in a neighbouring district, on the Soengei Sambas, it is seen overlying gold-bearing drifts, and is therefore younger than they. The author points out that neither the basalt nor the granite can be the matrix-rock of the diamonds, and, in disagreement with the recent favourable reports of English prospectors, he holds that the limit of exhaustion of the Landak diamond-field is already indicated by the geological facts.

The diamond diggings of Monggo, Mocara Behe, and Singgang, and those between Sikip and Engkangin, and between the last-named locality and Riam Melanggar are described in some detail. A curious instance of the reticence of the Chinese diggers is that, at Monggo, they would not tell the author whether the uppermost layer of the deposit was diamantiferous or no. Near Singgang Rapids are the only diamond-workings which the author saw carried on on a fairly large scale. Here sixty to seventy-five Dayaks were at work on small rectangular pits 10 to 16 feet deep, which are carefully timbered. But as the workings are, as a rule, below the river-level, the inrush of water has to be checked by every available means. The horizontal distance from one pit to another is never more than $3\frac{1}{2}$ feet. Some native gold is here associated with the diamonds. The method of washing the *areng* at these diggings is then described: it differs little from the methods which obtain everywhere in India in washing for gold, stream-tin, etc.

The Landak diamonds have a very good crystalline form, occurring mostly as octahedra, rhombododecahedra, and hexakis-octahedra. They are sometimes flawlessly water-clear, but, as a general rule, they have a more or less faint tinge of yellow, and a fairly large number are brown. As to dimensions, they rarely exceed 2 carats. A table is given of the production for the years 1876 to 1892, both inclusive.

The author then gives expression to his sense of disappointment at finding the "diamond mines" fall far short of the glowing accounts which had reached him on a previous visit to Borneo. He points out, however, that the country above Poelau is still a *terra incognita* to geologists, and he has grounds for deeming it not unlikely that there the matrix-rock of the diamond (possibly a crystalline schist) will be sooner or later discovered. He concludes with a scathing criticism of the so-called "mining engineers" and "mining experts" who have in recent years "boomed" the fields in their grossly exaggerated reports. O. S. E.

STEAM-JACKETS, AND THEIR VALUE IN A COMPOUND STEAM-ENGINE.

Du Rôle et de l'Efficacité des enveloppes de vapeur dans les machines Compound. By A. Witz. *Bulletin de la Société Industrielle du Nord de la France*, 1892, *vol. xx., pages* 317-355.

The author considers that there is no doubt about the value of a steam-jacket in simple engines, but wished to satisfy himself as to its value in multiple expansion engines, and especially in compound engines. He therefore conducted some careful and extensive experiments on a Dujardin engine of 625 nominal horse-power, with

compound cylinders. A full description of the engine, and of the manner of making the experiments is given, also of the rehearsals of the actual experiments which he was careful to have in order to avoid any hitch in the delicate work of measurement and recording.

He gives the state of opinion upon the subject as varying from Prof. Unwin's dictum that "there exists no carefully conducted experiment which proves that the jacket causes a loss," to the opinion of those who hold that the steam-jacket caused a positive gain of 16 to 25 per cent., while others believe that the gain varies as the need of the engine, and is beneficial as preventing the accumulation of water in the cylinders than in any other way, and that there would be no use for it if the steam was, and remained, dry. The conclusion the author came to at the end of his experiments was that in a compound engine the condensation of steam at its admission into the small cylinder was much less than in a simple engine, and the quantity of water present at the end of the stroke was less also. The jacket was therefore not so necessary, and it was less efficacious in compound engines than in simple engines. When the jacket was heated it gave a gain of 3·7 per cent. of steam consumed, when it was there but not heated the gain was 6·6 per cent. The best result was obtained by suppressing the jacket of the receiver; from the point of view merely of the amount of steam used, the receiver-jacket was condemned; its only use was in the increase of work it produced, but it charged too much for the service it rendered, for it condensed 8 per cent. of steam, while only 6 or 7 per cent. was gained at the piston. But the jacket on the big cylinder was useful, because the services which it rendered were greater than their cost. W. M.

THE METHODS ADOPTED IN EXPLORING THE KARWIN MINES.

Zur Gewältigung der Karwiner Gruben. By R. LAMPRECHT. *Oesterreichische Zeitschrift für Berg-und-Hüttenwesen, 1894, vol. xlii., pages 540-541 and plate XX.*

The means employed for clearing the Karwin pits, in which the disaster of June 14th, 1894, occurred, may be classified as follows:—

(1) Damming-off of all the levels opening into the Franziska, the Carl, and the Johann shafts, in close proximity to the shaft, with the help of respiratory apparatus. (2) The ventilation of the above-mentioned shafts; and, finally (3), the direct advance from all three shafts against the inflammable gases, coupled with the advance of a current of fresh air. This last operation to be, in case of need, facilitated by the piercing of boreholes from the surface.

Turning our attention to (1), the apparatus used in the operation of damming-off is figured in the plate which accompanies the original paper. To enable the workmen to set to work in a shaft filled with irrespirable gases, the air needful for breathing was led to them from the surface by an indiarubber hose. Air at a pressure of four atmospheres was forced into a receiver, and was led thence by an air-pipe to the reduction-valve. Through the hollow axle of the hand-windlass, the air at the reduced pressure of 1·1 atmospheres was led into the main indiarubber hose, which passed over a pulley to the cage. Here the main tubing branched into three lateral tubes led over the drums. Two tubes (for the masons) were 200 feet long, while the third (for the use of the signalman) was only 66 feet long. On account of its great weight, the main hose (820 feet long) was clamped in lengths of 164 feet, together with the electric signalling-wires, by easily displaceable clamps to the winding-rope. The workers were equipped with the Bremen respiratory apparatus, consisting of a helmet with indiarubber tubing. The

wearer could see through a glass plate in the helmet, so arranged as to be removed without difficulty. The air for breathing purposes, the pressure of which owing to the length of the main hose was reduced to 0·6 atmosphere, was led in at the neck of the helmet and divided into three channels, which terminated at the mouth of the wearer. The respired air was expelled through two valves placed one on either side of the helmet. The men had each a Bristol electric lamp secured to their bodies. Moreover, in the cage there was a supplementary air-reservoir, which was supplied from a branch pipe. The air required for the Galibert air-bags was taken from this reservoir.

Communication was ensured by means of the electric signalling-cable, which ran over a windlass and over a pulley to a signal-bell. As it was possible that through an accident the supply of air from the compressor might be interrupted, four air-pumps which could be easily brought into connexion with the rest of the system were held in reserve. In case of extreme danger, so soon as the signal was given, the ventilator of a shaft which communicated with the shaft undergoing clearance could be set at work. The operations were conducted only during the day. The workmen had shifts of three hours, and were then replaced by a fresh lot of men. The author noted from personal observation that after their three-hour shifts the men left the shaft without showing the slightest signs of exhaustion.

As soon as they stepped on to the cage to go down, the hatch closing the top of the shaft was drawn aside, and closed again immediately the cage had passed below ground. Above bank stood in continual readiness the directing engineer, the doctor, four men at the air-tube windlass, two men at the electric cable windlass, three men at either side of the hatch-shutter, one man at each of the four reserve air-pumps, one man at the signal communicating with the ventilator, and two men at the second staging. The last-mentioned guided the winding-rope, with the main tubing and the electric cable clamped to it, through their hands, so as to be able to check any backward motion which might occasion a rupture of the air-tubing. The cage travelled as slowly as possible in the shaft. At nearly every 100 feet signals were exchanged between the pit and the bank to make sure that all went well. The code of signals was as follows :—

. Stop; . . Let go cage; . . . Draw up cage; . . . . Not much air; . . . . . Don't understand; — . . . . Signal from bank that the workmen were to come out of the pit; — All's well, from below; — — All's well, from above; and — — — — — Help wanted.

It hardly falls within the scope of the present communication to explain in detail how account had been taken with an all but exaggerated minuteness of every accident likely to endanger the lives of the miners. And yet during the author's stay in Karwin one man was hurt. He broke the pipe which communicated with his helmet, and fell down insensible. His comrade tried in vain to press between his clenched teeth one of the two reserve-pipes from the Brass respiratory apparatus. The signal was, therefore, given to bring him to bank, and he was there restored to consciousness with the help of the doctor.

In the first half of September the chemical composition of the gases in the Franziska shaft was as follows :—Carbon dioxide, 3·5 per cent. ; oxygen, 0·8 to 1·5 per cent. ; methane, 58 to 60 per cent. The remaining gas was mainly nitrogen ; scarcely a trace of carbon monoxide was noted. After the complete damming-off of the levels opening into the Franziska shaft, zinc pipes were put down to ventilate the shaft.

Thereafter began the advance against the inflammable gases, coupled with the introduction of a fresh air-current controlled by suitable brattices. Before breaking

through the dams air-doors were built up about 6½ feet apart. Exactly the same means were employed in clearing the Carl and the Johann shafts. At the latter they were under the necessity of first getting out, by means of a derrick, the winding-cage which had been jammed in the shaft as a result of the explosions.

O. S. E.

ORIGIN OF THE SECULAR ELEVATION OF THE LAND IN SCANDINAVIA.

(1.) *Preuves et causes du mouvement lent actuel de la Scandinavie.* *By* A. BADOUREAU. *Comptes rendus de l'Academie des Sciences*, 1893, *vol. cxvii., pages* 767-769, 874. (2.) *Etude sur le soulèvement lent actuel de la Scandinavie.* *By* A. BADOUREAU. *Annales des Mines*, 1894, *series* 9, *vol. vi., pages* 239-275, *figures in the text and plate XIV.*

In these remarkable papers, the results of a journey to the Scandinavian shores in 1892, the author first points out that the causes of variation of the sea-level compensate one another in such wise that most geological observers regard the sea-level at any given point as constant, and they measure by it the position of the neighbouring lands when they proceed to determine whether those lands are undergoing gradual subsidence or elevation.

He enumerates in great detail the following proofs that the Scandinavian peninsula, as a whole, is rising:—

1. *Historical.*—The port of Luleå, founded by Gustavus Adolphus, is now far inland; the Stœtsund channel and the harbour of Landskrona have been gradually shallowing; 99 bench-marks placed on the Swedish and Finnish coasts since 1730 show an average rise of 0·79 inch per annum; 27 bench-marks placed on the Norwegian coast near Cape Lindesnaes in 1839, and observed again in 1865, also showed a rise.

2. *Zoological and Palæontological.*—The lakes of Finland and Scandinavia, besides a freshwater fauna of recent importation, contain species regarded as the residue of a cold salt-water fauna, which has gradually adapted itself to the new environment. This fauna includes a mammal (*Phoca annelata*) restricted to the Finnish lakes, fishes, and crustacea; and it is inferred that these lakes, before the elevation of the intervening land, communicated with the White Sea. But ere that communication was interrupted, these old fjords became freshwater lochs, much in the same way as the upper extremities of the Norwegian fjords nowadays lose their saltness. Rain, river, and infiltration-waters came in, freshwater ice formed on the surface in the winters, and the deep, dense, salt-water flowed away to the sea.

The recent coral termed by Linnæus *Oculina prolifera* lives at depths averaging 600 to 1,800 feet, but remains of it have been found by Sars in the Christiania fjord, from 420 feet up to sea-level. And in the island of Barholmen it occurs up to nearly 100 feet above sea-level, associated with remains of the bivalve *Lima excavata*. This would prove a rise of at least 650 feet during recent times.

3. *Geological.*—A brief sketch is first given of the successive glaciations and movements of submergence and elevation in Scandinavia from the commencement of the Quaternary period. Attention is then drawn to the old shore-lines now raised as terraces 600 feet and more above sea-level (raised beaches, cliffs of erosion, old river-deltas). In Southern Sweden, moreover, there are deposits of inter-Glacial coloured clay and post-Glacial white clay, which prove that the sea at two distinct periods formed a "sound" from Stockholm to Uddevalla, across what are now Lakes

Wener, Hjelmar, and Maelar. The *åsar* or eskers, being supra-glacier river-alluvia (*i.e.*, derived from torrents flowing on the surface of the glaciers), are not regarded as throwing any light on the present subject.

Conclusions.—The gradual elevation being demonstrated by these accumulated proofs, an enquiry into its origin has impelled the author to agree with Messrs. Drygalski and de Lapparent that the phenomenon is due to the warming of the earth-crust, which was either a result or a cause of the disappearance of the ice. During the last glaciation, Scandinavia and Finland were covered by an ice-cap 950 miles or so in diameter, and the temperature of the soil beneath it could, of course, never rise above 32 degs. Fahr. Now the mean annual temperature of the same area of surface-soil at the present time is 37·5 degs. Fahr.; and, taking into account the linear coefficient of expansion of the rocks, this would allow of a rise of 750 feet at the central point. De Geer's map of contour-lines of equal elevation (*isoanabases*) shows that the conditions of Scandinavia almost exactly correspond to the requirements of the theory. The state of equilibrium has not yet been attained, and the ascensional movement of the Scandinavian peninsula is still going on, but at a lessening rate.

A list of the more recent standard works on the subject accompanies the second paper. O. S. E.

GEOLOGY OF BALIA MAADEN IN ASIA MINOR.

Die geologischen Verhältnisse der Umgebung von Balia Maaden im nordwestlichen Kleinasien (Mysien). By GEJZA VON BUKOWSKI. *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften: Mathematisch-Naturwissenschaftliche Classe*, 1892, *vol. ci., pages* 214-235, *and plates I.-II.*

In this district argentiferous galena, which occurs at the contact of eruptive dykes with Carboniferous Limestone, has now been for several years worked by the Laurion Mining Company of Greece, under a concession from the Turkish Government. The chief workings are at Ari Maghara and Kodja Maghara, where suitable plant for cleaning the ore has been erected. After the preliminary cleaning it is sent by waggon or on the backs of beasts of burthen down to the coast at Aktchai. Thence it is shipped to Laurion for treatment at the smelting-works there.

Fossils show that the rocks of the district are partly of Triassic, partly of Upper Carboniferous (marine equivalents of Coal-measures) age. A short summary is given of the literature dealing with Carboniferous formations in Asia Minor.

The oldest stratified rocks are Carboniferous; they crop out chiefly in the south and east of the Balia Maaden district, and form the range of Aktchal Dagh (2,000 feet above sea-level). They comprise massive limestones of colour varying from light grey to black, dark-grey sandstones, and bluish-black shales. The sandstones and shales are subordinate members of the formation, and are repeatedly intercalated in the limestones. All these rocks have apparently been much disturbed, folded, and contorted. In a general way the strike of the Carboniferous rocks of Balia Maaden is from south-west to north-east, and this appears to hold good for the Triassic formations also.

The limestones are in some localities distinctly crinoidal in others foraminiferal, and in others again corallian and brachiopodal, but the actual succession of these different fossil-beds is difficult to determine on account of the above-mentioned

highly disturbed condition of the strata. The sandstones are apparently unfossiliferous, and in the calcareous shales only a few unrecognizable bivalves have been found.

The Lower Triassic consists of greenish-grey sandstones and conglomerates, and seems to be invariably marked off by a basement-conglomerate or extremely coarse grit, which, at its very lowest horizons, contains pebbles of the foraminiferal (*Fusulina*) limestones and Carboniferous sandstones. It is in some places seen to be plainly unconformable upon the Carboniferous. The Triassic sandstones become finer and finer-grained and more argillaceous as one goes upward—geologically speaking—in the series, and they finally merge into the greenish-black shales of the Upper Triassic. These are extremely rich in fossils. The dips change in so puzzling a way that in several localities the Trias appears actually to underlie the Carboniferous. The eruptive rocks of the district cover a large area in the north-west, and are mainly augite-andesites. In the neighbourhood of the Kodja Maghara mine the andesite shows a beautiful columnar structure. O. S. E.

ON ROLLED FRAGMENTS OF ROCK IN COAL AND ROLLED FRAGMENTS OF COAL.

(1.) *Sur des cailloux roulés de quartzites rencontrés au mur de la couche Grande Moisa du charbonnage de la Haye à Liége. By* Max Lohest. *Annales de la Société Géologique de Belgique*, 1893-94, *vol. xxi., pages lviii-lxv.* (2.) *A propos des cailloux roulés du houiller. By* G. Schmitz. *Ibid., vol. xxi., pages lxvi-lxxv.* (3.) *By* Ad. Firket. *Ibid., vol. xxi., pages lxvi-lxvi.* (4.) *By* Max Lohest. *Ibid., vol. xxi., pages lxxxv-lxxxix.*

(1.) These pebbles were found on the floor of the Grande Moisa seam at a depth of 2,022 feet. They are rounded fragments of fine-grained quartzite coated with a brilliant black layer showing striae. Under the microscope sections show rounded, sometimes angular, grains of quartz, cemented by quartz often containing carbonaceous or ferruginous matter. This structure shows that they are not concretions. No similar quartzite is known in the Coal-measures nor in the pebbles of its conglomerate. The presence of these pebbles is considered to be contrary to the theory of formation in place.

(2.) Pebbles are usually found in, or at the bottom of, the coal-seam, and not in the roof or neighbouring rock, where nodules of carbonate of iron are often found. The coating of carbonaceous matter found on the pebbles was accounted for by long transport in the midst of vegetable matter. It was concluded that the presence of pebbles supports the hypothesis of transport for the generality of the sediments of the Coal-measures, but not for the floors of the seams. Why not, it was asked, admit the accumulation of vegetation *in situ* in lagoons bordering the Carboniferous continent while rivers transported vegetable *débris* into the same?

(3.) Rolled pebbles have been found in the roof of the Crusny seam at the Plancher de l'Espérance colliery at Montegnée. From their form, they may have been fossil fruits filled with fine sediment. In the Saint Victor colliery at Turon there is a coal-seam formed of true coal-pebbles cemented together. The formation of such a seam could only be explained by denudation and transport.

(4.) It is suggested that the beds of coal-pebbles were originally beds of wood-pebbles. Such beds of rolled fragments are well known, and occur, for example, in the clays of Andenne, and in a modern fluviatile formation in the neighbourhood of Bayards (Liége). G. W. B.

CONDITION OF GOLD IN VEINS.

On the Condition of Gold in Quartz and Calcite-Veins. *By* A. Liversidge. *Journal of the Royal Society of New South Wales*, 1893, *vol. xxvii., pages* 299-303.

As a rule, the gold contained in massive quartz was free from any trace of crystalline form, and the larger the fragment the less crystalline form it presented. Crystallized gold was not usually met with in reef-quartz, but rather in the upper portions of the ferruginous and argillaceous casing of the reef and in the detritus near its outcrop. When the gold occurred in a soft matrix like calcite, clay, or serpentine, it was very often crystallized, as also when it occurred in cavities, such as those left by the removal of iron pyrites. G. E. C.

THE ORIGIN OF GOLD.

Analyse d'un mémoire de M. Noguès sur la genèse de l'or. *By* F. Lahille. *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 1892, *vol. xxvi., pages xxxi. and xxxii.*

Gold had been brought into its present deposits by the eruption of pyroxene-hornblende rocks (diorites, amphibolites, diabases, etc.), not in the condition of metallic vapours, nor by means of siliceous solutions, but in combination with iron and copper sulphides, arsenides, etc. On the subsequent decomposition of these the gold had been set free. Thus in specimens of dosimose (natural arsenio-sulphide of nickel) containing an appreciable proportion of combined but not visible gold, the mineral was oxidized to an arseniate, and the native gold was then observed in the free state. Diorites containing titaniferous magnetite were also pyritous and auriferous. The auriferous black sand of the Sierra de Peñaflor was derived from the denudation *in situ* of pyroxene-hornblende rocks; the crystals of gold, zircon, rutile, and pyrites which occurred in it had preserved their crystalline form intact. O. S. E.

THE ORIGIN OF GOLD NUGGETS.

On the Origin of Gold Nuggets. *By* A. Liversidge. *Journal of the Royal Society of New South Wales*, 1893, *vol. xxvii., pages* 303 *to* 343.

The paper gives details of a large number of experiments made with the view of determining whether a nucleus of gold immersed in a solution of gold, and in the presence of such substances as are likely to be met with in nature, would increase in weight. This was proved to be the case, although other experiments showed that a gold nucleus was not increased in weight in the presence of organic matter, as had been so often stated. Prof. Liversidge, however, expressed his conviction that large nuggets had not been formed from solution. He questioned whether the common assertion as to the greater fineness of nugget as compared with vein-gold had any foundation in fact. With fine alluvial gold there was such a difference, possibly because the silver and other impurities had been removed by solution owing to the larger relative surfaces exposed.

Gold was present in meteoric waters (though no absolute chemical proof had been brought forward), because it was found in recently-formed pyrites, etc., where it must have come from solution. Furthermore, large nuggets could be artificially produced by following the methods used in his experiments. In places gold was probably being so deposited at the present day, but the large nuggets had not been formed *in situ*. With gold grains and dust the case might be different, on account of the much greater surface exposed. G. E. C.

THE RELATIVE ABUNDANCE OF GOLD IN DIFFERENT GEOLOGICAL FORMATIONS.

By W. P. Blake. *The Engineering and Mining Journal (New York)*, 1892, *vol. liii., pages* 348-349.

The age of the chief gold-bearing slates of the central gold region of California, where gold was mined in greater quantity than ever before, was for a long time in doubt. The dogma of the Lower Palæozoic age of most of the gold rocks of the world predisposed observers to regard the auriferous slates as Palæozoic. But about the year 1864, the author had the good fortune to find Mesozoic fossils in the midst of these slates, and thus removed all doubt of their true horizon. These fossils were *Ammonites* in the slates of Placer county, near Colfax; *Belemnites* and Jurassic bivalves in similar slates on the Mariposa estate, Mariposa county, and contiguous to the great gold-quartz vein known as the mother vein of California.

Thus the Secondary age of the chief gold-bearing slates of California was established. In the great belt of Jurasso-Triassic, and perhaps, in part, Lower Cretaceous strata, enfolded in the western flanks of the Sierra Nevada, were found the strongest, richest, and most productive gold-quartz mines and placer-deposits of California. The mother vein at Carson Hill, in Calaveras county, had yielded some of the heaviest masses of gold ever taken from veins.

The occurrence of gold in California was, however, not confined to any one geological horizon. It was found in close contiguity to limestone of Carboniferous age, as early shown by Dr. Trask, and no doubt in the older rocks of the Sierra Nevada lying parallel with the chief auriferous deposits. Thus at Hite's Cove, some miles west of the locality of the Jura Trias fossils of Mariposa, there was an important gold-bearing vein near a stratum of limestone in which the author found encrinal stems, and which was no doubt Upper Palæozoic. But these older strata in California have never yielded gold so generally and in such profusion as the newer beds farther west of them.

On the other hand, some of the most valuable gold-mines did not occur in stratiform rocks. The celebrated veins of Grass Valley, California, which have been worked continuously for over forty years, are in crystalline granitic rocks of uncertain age. The great Comstock lode in Nevada, which had added so many millions to the world's supply of gold as well as silver, was in crystalline rocks which, however, were probably altered Mesozoic beds. The gold of the Deep Creek region, Utah, as the author has elsewhere shown, was in altered Carboniferous Limestone, thus being in Upper rather than Lower Palæozoic. J. W.

GOLD-BEARING ROCKS IN HONDURAS.

Esquisse géologique et minéralogique du District aurifère de Santa Cruz, Honduras (Amérique Centrale). *By* Alexandre J. Bourdariat. *Bulletin de la Société Belge de Géologie*, 1893, *Mémoires, vol. vii., pages* 35-40.

On the Atlantic watershed the auriferous deposits occur in gneiss, and on the Pacific watershed in trachytes. The gold in the former appears to be contemporaneous with certain diorite-outcrops, while the auriferous deposits in the trachytes show a greater abundance of gold and at the same time a larger percentage of silver ore. The richest mines in the country are those of Rosario, where the eruptive masses injected with rhyolite form the predominant rocks of the district. The annual production at these mines has continuously increased since 1887, when it was valued at 650,000 dollars. In the district of Villa Nueva, worked by the San Martin Mining Company, the gold and silver-bearing veins which

traverse the trachytes are characterized by the presence of an extremely friable, whitish-grey, talcose, clayey rock, containing small fragments of broken, highly siliceous rock, and charged with a quantity of gold and silver sulphide. This is locally nicknamed *jabon* (soap), and was the only stuff worked in the olden days by the Spanish miners. Elsewhere, as at La Concepcion mine, the veins become distinctly quartzose with a high gold and silver percentage.

Along the base of the Sierra del Spiritu Santo are ranged a whole series of gold-mining concessions. These have all been worked for periods varying from three to six years, after which, in most cases, mining operations have been stopped, the only really successfully-worked concession being that of Santa Cruz. It is to the description of the Santa Cruz district that the paper is mainly devoted.

Here the gold-quartz veins traverse schistose coarse-grained gneisses. Numerous hornblende-diorite dykes cut through the gneisses, and are always slightly auriferous. They appear to influence the quartz-veins (which they do not invariably traverse) in very different ways; sometimes the veins appear to grow richer near the dykes, sometimes poorer. The whole system of rocks has been much dislocated by steep faults. Six groups of veins are recognized in the Santa Cruz concession, and crop out over a fairly extensive area. Thus the outcrop of the Mandingua vein runs north-east and south-west for more than $1\frac{1}{4}$ miles, then disappears for a time, to crop up again in the Camelote Company's concession. All the veins are of the same age and of concretionary origin; they vary in thickness from 19 inches to 16 feet, frequently broadening all of a sudden into "rollings" where the quartz envelops lenticular masses of gneiss completely isolated from the country rock. But instead of becoming, as one might expect, richer in gold in these "rollings," the quartz appears to get charged with argentiferous galena. Small white "specks" of felspar are an invariable indicator of gold in the greenish-grey quartz of Santa Cruz. The band of reddish "crushed rock" which mostly runs parallel to the compact quartz is often the richest of the two in gold. The accompanying ores are sulphides of iron and lead, grey copper ore, mispickel, and natural alloys of gold with silver, platinum, and rhodium. But out of every 100 parts of gold in the vein, only 15 to 20 parts are, as a rule, combined with sulphides, the remaining 80 or 85 parts being free gold. The precious metal is, however, rarely visible to the unaided eye.

The quartz is crushed in contact with water and quicksilver in a 30 stamp-battery, set up on the Californian system. Such ores as are refractory to direct amalgamation are collected in the Frue-Vanner apparatus, and roasted for eight hours, during which operation they give off the contained arsenic and sulphur. They are allowed to cool, being subsequently treated in the amalgamation-pan. Even then difficulties arise; metallic arsenic in the form of fine dust encrusts the quicksilver, and impedes the process, wherefore the Plattner method is suggested as preferable. O. S. E.

WAVERLEY GOLD DISTRICT, NOVA SCOTIA.

Notes on some Special Features in Lode Formation and Deposition of Gold, as presented in the Waverley Gold District, Halifax Co., Nova Scotia. *By* B. C. Wilson. *Mining Society of Nova Scotia, Transactions, vol. ii., pages* 32-46.

The so-called auriferous veins of Nova Scotia are interbedded with slates and other rocks. Those at Waverley occur on an anticlinal running from east to west, broken near the middle by a north-and-south fault, which occasions doubt as to whether the veins on either side are identical. The anticlinal is most pronounced in the western division, the veins as you go westward becoming flatter; while at the extreme west exposure the vein may be seen to turn completely—one side dipping to the north and the other to the south.

The ore is free-milling, with a limited quantity of sulphides. The gold is usually fine, but occasionally extremely rich patches are met with. The sulphides are mainly arsenical pyrites, which, when embedded in the body of the quartz, is said to be usually rich in gold, but the reverse when it occurs on the walls.

The workings in the western division have reached a depth of nearly 400 feet. There is little or no underground water in the district, such water as is met with having come in from the surface.

In the eastern division, the vein, both at the surface and in depth, is "crimped" or folded upon itself, so that what would, if smoothed out, be a vein of 10 to 12 inches wide, folded together in this way, fills a space of 20 to 30 inches, and with the associated slate occupies a belt of 45 inches between the upper and lower walls of hard metamorphic rock. Where the surface-outcrop was laid bare, the vein looked like a layer of barrels, and hence received the name of "barrel lode."

That the vein was plastic subsequently to its formation is indicated by the fact that in some instances the quartz is found forced into wedge-shaped cavities in the walls, but so that its edges remain rounded, and a small angular space is left at the extremity of the crack, much as would be the case if putty were pressed into a similar cavity. G. E. C.

THE MINERAL RESOURCES OF SOUTH-EASTERN ALASKA.

By G. W. Garside. *American Institute of Mining Engineers*, 1893, *vol. xxi., pages* 815-823, *and map.*

The chief metalliferous belt follows the mainland shore in a north-west and south-easterly direction for more than 100 miles.

Gold is found in the free state, and is largely worked by hydraulic mining. The veins carry gold associated with sulphides of iron, lead, etc., with silver and lead ores, and with small quantities of copper, zinc, and iron ores. The most important district is the Gold Creek, where the well-known Treadwell mine is situated, on the east side of Douglas Island. A. W. G.

CRIPPLE CREEK GOLD-FIELD, COLORADO, U.S.A.

Notes on the Geology of the Gold-fields of Cripple Creek, Colorado. By H. L. McCarn. *Science* (*New York*), *vol. xxiii., pages* 31-35.

The Cripple Creek district is surrounded by granitic gneisses, altered towards the centre into a complex variety of schists, aplites, felstones, conglomerates, etc., all formed by metamorphism from the normal "granite," and all shading off into one another. Of these the best marked types are :—

1.—A grey felstone of leached-out appearance, often coloured yellowish, or brownish by iron oxides, finely granular, frequently containing small grains of pyrites. This, the porphyry of the miners, encloses many of the best mines.

2.—Mica-schist, of which there are two varieties. In one the mica is black and iron-bearing, the rock being friable; the other is a tough laminated rock with silvery-white muscovite. Good veins often occur at the contact between this and other rocks.

3.—Hornblendic felstones, mostly dark in colour, often very hard and compact. Evidence of bedding is sometimes visible, but stratigraphical study is difficult owing to the wash formed by atmospheric denudation, which covers the rocks sometimes to a depth of 80 feet.

The veins are unquestionably true fissures, as indicated by their crossing the bedding, the phenomena of slickensides, etc., and the gold occurs as usual in more or less vertical shoots. The country-rock is often fissured for some distance parallel to the veins, such quartz-filled cracks often yielding the richest stone. The clay-selvages also are often rich. The country-rock is often mineralized for considerable distances, so that the width of the vein cannot be measured.

Much of the ore is coated and impregnated with fine white auriferous pyrites, associated with sylvanite. Very few other valuable minerals are met with in the district. Limonite occurs as a veinstone, and also occasionally as the capping of the lodes.

Most of the veinstone is merely kaolinized "country." Variously coloured jasper occurs as a veinstone in some cases, the bright-coloured cryptocrystalline portions being reputed rich in gold. The author thinks that the gold was derived from the iron-bearing mica of the surrounding "granite," either directly or from pyrites derived from this.

Only two eruptive masses are known, neither of which has influenced the lode-mineralization. The more important is a dyke about 30 feet wide, dark grey to black in colour, showing minute grains of felspar in a matrix of amphibole or pyroxene. At one point a sheet of quartz is found between this and the granite, which is impregnated with copper minerals, evidently derived from the dyke. This is the only occurrence of copper in the district.

Most of the decomposed "wash," before referred to, is auriferous, and might be profitably hydraulicked if water were available. The absence of evidence of glacial or stream action accounts for the thickness of this wash, the valleys being synclinal troughs rather than valleys of erosion. G. E. C.

THE MOTHER LODE OF CALIFORNIA, U.S.A.

The Mayflower Mine, California. ANON. *Engineering and Mining Journal* (*New York*), 1894, *vol. lvii., pages* 173-174.

The mother lode is a band of graphitic slate, seamed with quartz-veins, and bordered by walls of greenstone, forming part of a belt of slates and eruptive rocks, which runs north and south parallel to the Sierra Nevada for over 100 miles, with an easterly dip. Owing to its greater hardness as compared with the enclosing rocks, its outcrop stands up in conspicuous masses. The quartz bodies occupy irregular fissures in the slate and greenstone, sometimes crossing both dip and strike, but generally conformable They are thus classed :—

1.—Hanging-wall veins mainly on the contact between the slate and the eastern greenstone wall.

2.—Foot-wall veins irregular and of limited extension.

3.—Counter veins, of little importance excepting as indicators.

4.—Greenstone veins, quartz-filled fissures in the greenstone walls.

Recent experience on the mother lode indicates the existence of two separate ore-bearing horizons. The first extends from the surface to a depth of 600 or 700 feet ; this is followed by a barren zone, and subsequently another rich zone extending from about 1,100 feet to the lowest depths yet reached. G. E. C.

IRON ORES IN THE FRENCH PYRENEES.

Note sur les Richesses minérales des Pyrénées orientales. *By* CHARLES HELSON. *Annales de la Société Géologique du Nord*, 1893, *vol. xxi., pages* 159-169.

After being more or less extensively worked for many centuries, the mines in the French Pyrenees were abandoned at the time of the Revolution of 1789, and only within very recent years have operations been restarted in some localities. Two of the main factors which apparently determined this long abandonment, namely, the want of sufficient mechanical power and the want of cheap and rapid means of transport, can be now easily eliminated.

The metalliferous deposits of the Department of the Eastern Pyrenees are grouped around the base of the Canigou: in the west, especially in the neighbourhood of Prades, and in the east in the districts of Batère, Ballestavy, and Velmanya There are 27 concessions for iron-ore mining in the Department, occupying a total area of about 25,000 acres. By far the most extensive, and the only claim actively worked, is that of Fillols, supplying ironworks in the south of France. Capital is the one thing needful to develop the others.

The ferruginous deposits are in the form of veins, layers, and pockets in saccharoidal limestones, and in clay-slates resting on the older granites. Near Prades, they strike east-and-west along a line more than 12 miles in length: the average thickness of this ferruginous band is 65 feet, but in the Batère-Velmanya group it increases to double that measurement. The ores are exceptionally rich: they consist chiefly of magnetite, hæmatite, and decomposed iron carbonate, all of which are manganiferous. Tables of analyses of the Constantine (Algeria), Bilbao, and French Pyrenean iron ores are given, showing that the last-named suffer no disadvantage in the comparison. Thus at Velmanya the percentage of metallic iron in the ore is 64·5, at La Pinouse it is 60 and 62, according to determinations made in the Paris School of Mines.

Various authorities are quoted in support of the view that a brilliant future awaits this comparatively neglected mining field, and the author is sanguine enough to think that France can supply herself with iron ores from the Pyrenees to the complete exclusion of foreign imports of ore. He states that the new railway rates will allow of the Pyrenean ores being put down at St. Etienne, Creusot, Alais, etc., at prices defying any possible competition, and Port Vendre being only 50 miles away, the ores could be sent by sea to the Northern French and Belgian ironworks. O. S. E.

THE HÆMATITES OF NASSAU, GERMANY.

Das Vorkommen der devonischen Eisen-und Manganerze in Nassau. *By* WILHELM RIEMANN. *Zeitschrift für praktische Geologie*, 1894, *pages* 50-57, *with figures in the text.*

The iron and manganese ores of Nassau occur in the Devonian formation of the districts of Wiesbaden and Wetzlar. The rocks form a great complex of squeezed, uptilted, and overthrust quartzites, grauwackes, slates, and limestones, cut through here and there by diabases, porphyries, and basalts. The general strike is south-west and north-east, the dip south-easterly.

From the miner's point of view the highly fossiliferous Stringocephalus-limestone (Middle Devonian) is of importance, because of the manganiferous brown iron ores associated with it. It is in part massive, and is then largely burnt for cement, in

part weathered, "ragged," and dolomitized. In some places the limestone is so highly impregnated with iron oxide that it makes an excellent flux for the blast-furnace.

The Upper Devonian Goniatite-limestones make good building-material, and often become very ferruginous where they form the hanging-wall of the red hæmatite-deposits. The schalsteins or greenstones are the constant associates of these deposits, particularly in the Lahn basin.

Considering, first of all, the brown iron ores, these may be classified as follows:—

(*a*) Those filling up fissures in the rock, or inequalities in the very irregular surface of the Stringocephalus-limestone, where that surface does not come to day. The ores are manganiferous and occur especially where the limestone passes into dolomite, or has become entirely dolomitized. They are generally separated from immediate contact with the limestone by a thin layer of clay. In the Ebersgöns and Oberkleen mines the limestone "footwall" is nowhere dolomitized, the "hanging-wall" is Devonian slate, and the deposits may be regarded as true contact-formations. Manganese ores are of rarer occurrence.

(*b*) Those occurring in decomposed greenstones. The ores are found in reniform masses, in nests, in pockets, and in layers of inconsiderable extent. They are highly siliceous, and, containing only 30 to 35 per cent. of iron, are of small industrial value.

(*c*) Those deposits overlying the Upper Devonian, where, besides the forms mentioned in the previous group, they are found also as veins.

So much for the brown hæmatites; the red are of more importance in the area under review. In some rare cases they cut through the strata as "veins," but, as a rule, they are regularly interstratified with other beds, and are, from the point of view of position, of an origin contemporaneous with that of the "country rock" (mostly Upper Devonian). It is possible, however, that they were originally limestones which, by taking up iron oxide, have gradually passed into hæmatite. They are very irregular in thickness, in some places attaining 65 feet, at others thinning away to nothing, and they generally occur along the boundary between two different rock-facies. Where the deposits are valuable, the "country rock" is, as a rule, much weathered. In some of the Lahn Basin mines the ironstone becomes more calcareous the deeper it is worked, and passes into limestone-beds. In others it becomes highly siliceous, but it would be a mistake to generalize from these observations, and the author does not subscribe to the opinion that below the level of the valley-bottoms the deposits on the whole become unworkable. He adduces many examples to the contrary; at the Raab mines, to take one instance, the ores at 393 feet below the adit-level are richer than those struck at that level. The red hæmatites contain generally 40 to 50 per cent. of iron, but cases are known where they contain as much as 69 per cent.

In addition to the deposits previously described there are the so-called "rolled deposits." They consist of ironstone-gravels lying at or near the surface, often on the slopes of such hills as have at a higher level outcrops of hæmatite-deposits proper. It is clear that these gravels are derived from the aforesaid deposits, and are a recent alluvial or drift-formation. They are worked chiefly at Oberndorf, and the hæmatite from them contains on an average 56 to 59 per cent. of iron. They are practically free from phosphorus, and are therefore specially adapted to the Bessemer process. Magnetite, spathose, and specular iron ores are in places associated with the hæmatites.

The number of mines at work is 216, employing in round numbers 6,000 work-people, and producing annually between 750,000 and 800,000 tons of iron ore and 15,000 tons of manganese ore. O. S. E.

THE MESABI IRON-RANGE, INNESOTA, U.S.A.

By H. V. Winchell. *Transactions of the American Institute of Mining Engineers, vol. xxi., pages* 644-686.

The Mesabi iron range extends for 140 miles from the Canadian boundary in Minnesota to beyond the Mississippi river.

The width of the ore-belt varies from 1 to 2 miles. The ore lies in nearly flat beds, varying in thickness up to 100 feet. To the eastward it is hard, black, and magnetic, due probably to the heat of the gabbro which has flowed over it, while in the centre and west it contains soft and hard hæmatite, limonite, and goethite.

The ore is deposited in regular beds, constituting part of the Taconic strata, and not in veins with hanging- and foot-walls as is popularly supposed.

The writer concludes by giving a number of analyses of the ores, describing mines already opened, and the method and cost of mining. A. W. G.

THE MAGNETIC IRON-ORES OF ASHE COUNTY, NORTH CAROLINA, U.S.A.

By H. B. C. Nitze. *Transactions of the American Institute of Mining Engineers, vol. xxi., pages* 260-280.

Ashe County is in the extreme north-west of North Carolina, and the ore-deposits are situated in the area of crystalline rocks consisting of gneiss, and hornblende and mica-schists.

The district is practically undeveloped, and covers an area of about 150 square miles. The ores are principally magnetites, suitable for the manufacture of Bessemer pig-iron, brown hæmatites and specular ore being also found. The structure of the magnetite-beds is undoubtedly lenticular.

The district is divided into three main belts. The Ballou or river belt, the Redhill or Poison branch belt, and the Titaniferous belt, the last of the three being apparently the most important. Generally, the ores are of good quality, low in sulphur, and below the Bessemer limit in phosphorus. Though containing much silica, high-grade products could easily be obtained by magnetic concentration.

A. W. G.

THE ZINC AND LEAD MINING DISTRICT OF RUBLAND (CARINTHIA).

Die Zink-und Bleierzbergbaue bei Rubland in Unter-Kärnten. By R. Rosenlecher. *Zeitschrift für praktische Geologie*, 1894. *pages* 80-88, *with map in the text.*

Limestones and clay-slates are the predominant rocks of the area. The limestones are generally of an uniform colour, varying from light silver-grey to deep iron-grey, the darker ores containing small carbonaceous particles of a dense black hue, and emitting a fœtid odour when struck. There are some thin beds of a black seamed limestone, similar to that associated with the galena and calamine-deposits of Raibl. The limestones are, in many localities, traversed by innumerable veins of calcite, which are somewhat optimistically regarded by the miners as forerunners of ore-deposits. The general dip is 40 to 45 degs. north towards the Drave valley; the limestones probably belong to the lower division of the Upper Trias.

The clay-slates or shales are strongly bituminous, and abound in pyritous concretions: they are of a very dark-grey colour, almost carbonaceous in aspect. In some few cases they pass gradually into the limestones, but, as a rule, they are sharply marked off from these by a thin, soft, decomposed clayey layer. They are very irregular in thickness, in dip, and in strike, and are much fissured.

Of less importance are the deep red, strongly ferruginous, flaggy sandstones, which occur in the northern part of the district.

In the above-described complex of limestones and shales lie the ore-deposits, their mode of occurrence being so irregular as to give few clues from which the prospector may safely generalize. There are, however, good grounds for believing that they were formed by the circulation of fluids, holding the ores in solution, along the system of fissure- and joint-lines in the limestones, but near the contact with the shales. Tectonic considerations show that the whole complex was thrust up by contraction of the earth's crust, and the difference of elasticity between the limestones and the shales must have induced great fissuring of the former rocks, particularly near the contact with the latter.

Mining has lately been for the third time resumed in the district, the zinc ores being the most prized, whereas under the old conditions the lead ores alone were worked, the zinc ores being left in place or tipped on to the wasteheap. The thickness of the ore-deposits does not usually exceed (0·50 to 0·75 metre) 1·64 to 2½ feet, but in some cases it becomes as much as (2 metres) 6·56 feet.

The minerals composing the ore-deposits are the zinc-blendes, of a clear honey yellow to a light greyish yellow colour, galena, heavy spar, pyrites, anhydrite, in separate crystals or fissure-surfaces and in hollow cavities, and quartz in a state of microscopically fine division. According as one mineral or the other is predominant, the miner strikes plumbiferous blende-deposits or blende-bearing galena-deposits. True calamine has not thus far been found in the Rubland district, but the term "calamine" is locally applied to hollow masses of blende which yield on hammering a nucleus of good zinc-blende, and are merely weathered a little externally.

At the first glance the ore-deposits appear to be scattered haphazard over the district, but on looking at the author's sketch-map one is enabled to distinguish three separate "tracts" or lines of deposits ranging practically parallel to the southern mountain-chain ($\frac{1}{4}$ and $\frac{1}{2}$ mile apart respectively), and crossing the district almost due east and west.

Mining operations in this area are attended with great difficulties, and with considerable risk to those who undertake them. A good deal of capital needs embarking in the enterprise to secure satisfactory results. The methods of working afford no striking particularity, but it is worth while noting that the ores are washed in the Koflach Graben by means of plant driven by turbines, the installation permitting of 60 tons of "small" to be passed through the washing apparatus every twenty-four hours. The washed ores are taken 4¼ miles by a steep waggon-road to the nearest railway-station. O. S. E.

IRON GLANCE AND MAGNETITE ARTIFICIALLY PRODUCED FROM THE IRON RESIDUES FROM ANILINE WORKS.

Künstliche Bildung von Eisenglanz und Magnetit in den Eisen-rückständen der Anilinfabrikation. By Dr. Wilhelm Müller. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1893, *vol. xlv., pages* 63-68.

For some little time past the residues from aniline factories have been worked up in the Phœnix blast-furnaces at Laar, Ruhrort. Premising that the necessary hydrogen for obtaining aniline from nitrobenzol is produced by the reaction of hydrochloric or even acetic acid upon metallic iron, the author states that the ferruginous mud, which remains after the aniline has been distilled off, is allowed to settle on draining-floors, and when it has assumed a more pasty consistency it is taken away to the ironworks where it is shovelled out into heaps which lie in the open.

Under the influence of atmospheric air very active oxidation is set up in these heaps, and goes on to such an extent that they frequently become incandescent. Indeed, it is stated on the authority of Mr. C. Reinhardt, the superintending analyst of the ironworks, that some of the barges carrying these residues have been known to take fire—probably from the same cause. The process of oxidation is accelerated by the organic substances present among the residues. It implies, of course, considerable chemical change—a change emphasized by a remarkable transformation in the physical characteristics of the mass. The colour changes from blackish-brown to red, the stuff hardens so that it has to be broken up with pickaxes to be got into the furnace, the organic substances originally present disappear, and those parts of the mass which have been most heated have assumed a perfectly metallic aspect, brilliant lustre, and steel-grey colour. In these are numerous hollows lined with well-shaped crystals. Careful examination proves these to be intergrowths of magnetite with iron glance. In nature, such intergrowths are known in the fumaroles of Vesuvius. O. S. E.

MANGANESE IN THE CAUCASUS.

Engineering and Mining Journal (*New York*), 1892, *vol. liv., page* 28.

About 26 miles from the station of Kvirily, on the Transcaucasian railway, manganese ore was discovered some years ago in very large quantities and of a superior quality.

The quantities of ore are stated to be very large, as the surface of the manganiferous lands is said to be no less than 84 square miles. The ground belongs to a great many proprietors, mostly peasants, and the extraction of the ore is carried on in a primitive way. The cost of mining varies from 2s. 6d. to 4s. per ton; the proprietors are paid about 2s. 6d. per ton; the carriage from the mountains and to the railway station varies from 24s. to 32s. per ton, and the railway carriage from Kvirily to Poti amounts to 8s. per ton. The price of the manganese ore on board ship at Poti (Black Sea) is about 36s. to £2 per ton. J. W.

MARBLE QUARRYING.

By G. W. Perry, Ph.D. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii., page* 207.

The invention of the diamond drill and the channelling-machine changed all methods of marble quarrying. As marble lies in a solid mass and breaks irregularly and with difficulty, it cannot be split or rifted out like some other kinds of stone. Therefore it is necessary to cut almost or entirely around a block, a long and tedious process by hand drills. When a quarry was worked by hand, one with a slight dip was valuable, as deep openings could not be made; but now, the greater the dip the more valuable, because the sooner sound stock will be found. Then the blocks were very small, just large enough for the tombstones of those days, and they must, therefore, conform to the grain of the stone. Now they range from 5 to 20 tons in weight, while, for special purposes, much larger blocks are taken out. Then the stratification was followed of necessity after the unsound material near the surface was blasted off. In the Sheldon quarry, Vermont, the old hand workings may be seen on the right, showing the dip to be about 60 degs. As before said, the stone lies in one solid mass, the lines simply showing the cutting of the blocks. It has been found by experience that it is not best to blast off even the unsound stock lying near the surface, as the shock is likely to shatter the stone for some distance below, and if the effect does not show at once, cracks are apt to appear upon exposure to the weather. The machines are put at work upon the top of the deposit, and the unsound blocks are patiently taken out and thrown into the dump heap.

The opening made is not very large, as the marble is sounder and more valuable at a depth. By means of the machines it is possible to cut under the side walls, thus making the floor of the quarry much larger than the top, great columns and buttresses being left as supports.

The channelling-machine is like a little locomotive, running upon a narrow-gauge steel track. As it travels it strikes on one or both sides of itself with a set of five drills set at different angles. Thus going back and forth upon the floor of the quarry it cuts a channel about 1½ inches wide to a depth of 6 feet. A double machine will cut as much as fifty men. There is thus cut a long block still fast on its bed and at the ends. The machine is now turned around and the long strip cut into blocks about 8 feet long, which are now free, except at their beds. One of these must be partially sacrificed in order to make a working-place from which the others may be operated upon. A hole is drilled in the centre of one of them to a depth a little below the channel, and a small blast of powder then will easily lift it. In the opening thus made a diamond drill is placed, and holes are drilled about half through the blocks under their beds, when they can be easily wedged off. When once the first has been taken out, then all the others on that floor can be broken into blocks by the diamond drill or the gadder, these being broken along the lines of stratification, instead of at right angles with the surface. J. W.

THE QUICKSILVER MINES OF TUSCANY.

Die Quecksilbergruben Toscanas. By R. Rosenlecher. *Zeitschrift für praktische Geologie,* 1894, *pages* 337-353, *and plates IV.–V.*

The central point of the Tuscan quicksilver mining district is the volcanic peak of Monte Amiata (5,687 feet high), which is the result of an eruption in Oligocene times. The trachytes cover an area of 25,000 acres, and their outflow was doubtless the determining cause of the fissures in the neighbouring rocks which were subsequently filled with metalliferous ores. Eastward rise the Nummulitic Limestone crags of the Monti Civitella, La Penna, and Nebbiaio; southward and westward, ever diminishing in height the farther south one goes, range the undulating ridges of Middle and Upper Eocene limestones. Miocene sands, with sometimes a calcareous sometimes a ferruginous cement, crop out near Pian Castagnaio and form the summit of Monte Buono; they are, so far, barren of fossils. Patches of Pliocene, consisting of a calcareous shell-breccia, are scattered here and there over the district.

The chief line of fissure strikes north and south, and is crossed nearly at right angles by another series of fissures. The most abundant and richest metalliferous deposits are at the points of intersection of the two systems; farther away from the main fissure-line the deposits get sparser and poorer.

In the Monte Amiata trachyte in small pocket-shaped cavities are deposits of bole and yellow and brown ochres, particularly near the contact with the limestones. Numerous springs gush out from the trachyte, and in the height of summer the rich vegetation on this rock presents a striking contrast with the sun-scorched, burnt-up district to the southward.

Serpentines of Eocene age occur at various points, and at the contact with the stratified rocks some small finds of cinnabar have been made. Below the oldest Eocene strata come Globigerina-limestones of Senonian age, followed in descending order by shales, strongly manganiferous, and containing flint in bands and nodules. These are underlain by a much fissured limestone with masses and bands of flint in its lower portion, and having many large and irregular cavities. The cavities at Cornacchino, to take one instance, will be alluded to further on. This limestone is

on an average 65 feet thick; below it is a great flinty formation 130 feet thick, full of clefts and cracks which contain cinnabar—sometimes these clefts widen out into small chambers filled with clay impregnated with cinnabar. This impregnation extends also to the limestone which comes below the flint, and is possibly of Jurassic age.

Besides occurring in the trachyte near Abbadia San Salvatore, cinnabar is found in all five of the stratified formations of the district, in the Pliocene, Miocene, Eocene, Neocomian, and Jurassic. Diverse as the character of the deposits may be, their common origin from solfataric springs which held in solution cinnabar and other sulphides is evident, and they may be all ranged in the one category of "impregnation-deposits." The hydrogen-sulphide springs and gas-wells which still abound in the district lend confirmation to this view.

Among the most characteristic occurrences of the quicksilver ores are those at Siele, Solforate, Cornacchino, Montebuono, and Abbadia San Salvatore.

The Siele mine belongs to a Leghorn firm, and is one of the most considerable in the district. Here, in Middle Eocene limestones and shales, forming a complex about 165 feet thick, are flattened "pockets" filled with a dark grey clay, veined with calcite, and termed by the Tuscan miners *biocca*. In this are embedded iron pyrites and cinnabar, more or less concentrated at one point, or sometimes evenly dispersed throughout the mass. The richest deposits contain ores yielding as much as 60 per cent. of metallic mercury; in such cases the red colour peculiar to cinnabar permeates the clay. Other ores occur, in a state of very fine division, containing 10 to 15 per cent. of metallic mercury, but, as the daily and monthly statistics of the mines show, the true general average is 5 to 6 per cent. The best part of a "pocket" is generally near its lower end, where it contracts funnelwise into a narrow tube, through which, probably, the inflow of the metalliferous solutions took place. The average longitudinal extent of the "pockets" is from 160 to 260 feet, vertical from 130 to 160, and thickness $3\frac{1}{4}$ to $6\frac{1}{2}$ feet.

A long adit, not very many feet above the level of the Siele stream, led in former days to shallow shafts, mostly provided with steps, but within the last few years two vertical shafts have been put down, one of which (174 feet) is used as a reserve and pumping shaft, the other (820 feet) for haulage and drainage. The last-named shaft is elliptical in cross-section (area 10·17 by 8·85 feet), and is almost entirely lined with blocks of trachyte. The haulage engine is a single-cylinder condenser of 40 horse-power: the ores are taken direct from the pit-mouth, along a small incline a couple of hundred yards in length to the roasting-ovens.

The geological conditions obtaining at Solforate are very similar to those above described at Siele, but the appliances at the former mine are primitive and the method of working incredibly negligent: a great drawback also at Solforate is the want of water.

At Cornacchino we come to the second most important mine in the district of Monte Amiata, opened only in the year 1879. Here the cinnabar occurs at three distinct geological horizons, whose outcrops may be easily followed above bank, namely, the Lower Neocomian Limestone, the Cretaceous flint-rock, and the Jurassic Limestones below these.

In the flint-rock the narrow clefts are full of a sandy loam impregnated with cinnabar, which is extraordinarily free from pyrites. But mining did not pay here until the hanging-wall of Neocomian Limestone by chance revealed in it the presence of cinnabar-deposits. These are of very irregular form, and are richer in the marly than in the tough compact limestones. In the former, the cavities filled with cinnabar-clay or "nests" seldom measure more than 8 to 10 feet vertical and 5 to $6\frac{1}{2}$ feet horizontal. The "nests" are connected one with the other by very small

cracks ("canals"), which acted as so many pipes for the passage of the mineral solutions. In the tough limestones the ores occur as lodes of insignificant thickness. In the highly-decomposed limestones much of the calcareous matter has been leached out, swept away, and replaced by masses of grey and yellow pyritiferous clay impregnated with cinnabar. These masses sometimes measure 3,000 or 4,000 cubic feet, sometimes less than 100. The distribution of the ore, too, is irregular, and the average percentage of metal is 1 to 1·5. In accordance with the hypothesis that the metalliferous solutions came from below, the most recent exploring operations have revealed the presence of cinnabar-deposits in highly decomposed Jurassic limestones beneath the flint-rock.

The workings at the Cornacchino mine were formerly conducted in the most unmethodical fashion. Rich and easily attainable deposits were worked out, just as they happened to be found, while poorer deposits were passed over, with the result that the production was extremely fluctuating, and finally sank to *nil*. But in recent years, with the advice of the author, working was re-started on a systematic plan, and so far with the best results. Drainage need not be considered in a mine where the impermeable shales which form the roof keep the workings practically watertight.

From the upper horizons the ore is slid down shutes or small vertical shafts, known as *caminetti*, to the floor of the main level, where it is loaded into tubs and hauled up to bank. Ores in the flint-rock have of late been scarcely worked at all, and, as above-mentioned, the average percentage of metal in those that have been worked is 1 to 1·5.

They are therefore dressed for smelting by a very simple buddling process, the product of which is a mass usually containing 15 to 30 per cent. of metallic mercury, and this is dry-distilled in two retort-furnaces; poorer stuff is simply calcined in a blast-furnace fired with charcoal. The maximum production ever known at this mine is 400 to 500 bottles of mercury per month (each bottle containing 76 lbs.), the number of workpeople averaging 100 to 120.

The Montebuono mine, on the northern side of the mountain of the same name, is the southernmost of the quicksilver mines that are now worked. Here the Miocene sands overlie and conceal the Nummulitic Limestone. When the workings were driven down about 100 feet through the sands, a great vertical crevice, 6 feet or so wide, was struck. It appears to split the whole mountain, and is no doubt one of the results of the ancient volcanic outbursts of Monte Amiata. This crevice is filled up with Miocene sands and clays impregnated with cinnabar in an extremely fine state of division, and in the immediately neighbouring rock are several funnel-shaped cavities also filled with metalliferous sands and clays, the proportion of cinnabar increasing with the depth from the surface. On the whole the average percentage [of metal] is 0·4 to 0·5.

The workings comprise three levels, the highest of which is already worked out, the lowest is in forewinning, and the middle one is in active working. The vertical distance from the deepest to the middle level is 121 feet, and from the middle to the highest 98 feet. The ore is slid down a small shaft to the floor of the lower level, and loaded into tubs which run along rails to the smelting-works. On account of the state of fine division of the cinnabar, the attempt to enrich the ore-stuff by buddling as at Cornacchino proved ruinous, and the stuff is smelted direct as got from the mine in a Czermak calcining-furnace, with movable bars and an iron condenser. Eighteen to twenty metric tons are dealt with every twenty-four hours, and the fuel is beech and oak-logs (daily consumption, 247 to 282 cubic feet). The number of workpeople at this mine is sixty to seventy, the daily production averages 66 to 88 lbs. of mercury, and as the cost of working has to be distributed

over this quantity, the profits are small. But there is good hope of striking some richer and better paying deposits in the mine, as the workings are carried deeper down.

At Abbadia San Salvatore, the northernmost point of the quicksilver district, the trachytes form a kind of bay cutting into the mountain-massif proper. In this bay lie along an east-and-west line several points where ore has been found, and the prolongation of the line leads direct up to the summit of Monte Amiata This leads to the inference that we have here a radial fissure through which the metalliferous solutions found their way upward. Some workings have been started in the trachyte, but have not been carried further than the experimental stage. The rock is decomposed almost to a sand, and appears at the first glance extremely rich in cinnabar, but, despite its fine colour, the metallic content is less than 0·1 per cent. Moreover, water comes in with such force that powerful pumping-engines are needed to deal with it, and really cheap fuel is not to be had for firing them.

At the contact of the limestone and trachyte, however, a loamy band about 20 inches thick contains masses of pure cinnabar several pounds in weight, and a great many less pure reniform and lenticular nodules of the ore. In view of this promising outlook the winning was actively pushed forward, despite a considerable inflow of water, but soon the workings were overwhelmed by great masses of quicksand and loam, and were perforce abandoned. The miners are driving a gallery through the trachyte, so as to get round this bad place, and intend to strike the contact-rock nearer the mountain-summit. Similarly, the forewinning in the Eocene Limestones themselves promised excellent results, but was interrupted by the invasion of quicksand, and there the workings had to be given up entirely.

Besides the localities to which particular attention has been drawn, exploration and forewinning operations have been tried at several other points in the district, but they have resulted mostly in failure. Insufficient capital and want of perseverance and technical knowledge partly account for this, and partly also the insuperable obstacles which the Tuscan landowner often puts in the way of the miner, for the old law that the minerals belong to the owner of the soil still prevails.

Quicksilver mining in the Monte Amiata district is, comparatively speaking, an industry of quite modern growth. The conditions of wages and labour are favourable to enterprise, and difficulties of transport have vanished. There are excellent roads and new railways in the district. Wood fuel from the forests stretching away towards the Maremme is still to be got in abundance. For all of which reasons the author is hopeful as regards the future development of the industry. O. S. E.

NOTES ON THE WHITE MICA DEPOSITS AND MINES OF THE SAGUENAY REGION, CANADA.

By J. Obalski. *Canadian Mining and Mechanical Review*, 1894, *vol. xiii., page* 7.

The first working in the Saguenay region dates back only to the end of 1892. The country rock is mainly felspathic and dioritic gneiss of Lower Laurentian age, frequently covered by trap-dykes.

The mica occurs in veins of coarse granite, generally bearing about north-east. Of these fifteen were noted; but in many cases the mica-crystals were too small, or the veins too narrow, for profitable working. It is always white (muscovite), brownish when in thick crystals, as distinguished from the green crystals of the Ottawa region. It is clear, free from spots, elastic, and possesses good cleavage. In two cases only, the McGie and Beaver Lake mines, has work been done as yet on any considerable scale, both of these being in the Bergeronnes township. As the workings are situated about 12 miles from the St. Lawrence, the cost of transport will not be excessive. G. E. C.

TRADES UNIONS

Rapport sur les Syndicats professionnels. Bulletin de l'Union des Charbonnages, etc., de la Province de Liége, 1892, *pages* 138-150.

In France, trades unions are regulated by the law of March 21st, 1884. The legislature of 1791 found that unions, formed at first to resist the feudal oppressions, were becoming in their turn sources of danger to the efficiency of industry and the freedom of the subject. They, therefore, at that time suppressed the right of association among the industrial classes.

The law of 1884 was framed to repeal the penalties imposed by the laws of 1791, and was meant to give complete liberty of association. By this law either workmen or employers may continue together for their own purposes, but it still remains a penal offence to attempt to raise or lower wages or to interfere with the liberty of trade or work by means of violence, riot, threats, or fraudulent manœuvres. By this Act the law of France is made the same as it has been for a long time in Belgium, with one exception, viz., the Belgian law considers moral coercion in the same light as physical violence, and punishes those who attempt to enforce any proscription or fine, either against workmen or employers.

Several restrictions are imposed upon the unions in France as to the property they may hold, and the registration of their offices and directors. Unions are at liberty to combine together for the purposes of education, or the defence of their interests. Proposals are being made to amend the French laws so as to permit unions of masters and workmen to combine together for charitable purposes. Those proposals, however, have always been defeated by the fear that they might be used for the propaganda of the Roman Catholic religion. An account is also given of the laws regulating the trades unions in Great Britain.

In Germany, the unions are regulated by the laws of 1881 and 1884, and these laws are found to work satisfactorily. One provision is that an employer cannot have apprentices unless he be a member of the corporation of his trade. These corporations are formed into groups, said to resemble trades unions, one of the most important being the Union Hirsch.

In Belgium, the associations are regulated by the common law, but since 1889 the Chamber of Representatives has been engaged with a proposed law conferring on the unions the benefit of *personnification civile*. The object of the bill is to permit unions to receive donations and legacies, and the unions would also have the same rights with regard to real property as are enjoyed by private citizens. This law has not yet been passed, but an interesting account is given of the various arguments for and against the project. R. W. D.

UTILIZATION OF ZINC FUMES.

Verfahren zur Verwerthung des bei den Zinkblende-Röstofen fallenden Flugstaubes. By G. Krause. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1891, *vol. xxxix., page* 152.

The zinc which is present in the fumes as a sulphate (10 to 21 per cent.) and the iron (as ferrous sulphate, 2 to 3 per cent.) are washed out of it and precipitated by an alkaline carbonate. In this way an artificial calamine, containing from 45 to 50 per cent. of zinc, is produced and calcined into a stiff mass, which is then subjected to the ordinary processes of zinc manufacture.

In one sample tested the sodium sulphate obtained as a by-product was of sufficient value in itself to cover the cost of extraction of the zinc and iron from the fume. Great economy is also effected by precipitating with barium nitrate the solution of sulphates obtained in washing the fume, and then washing the filtrate and precipitating with sodium carbonate as before, the products of the whole process being calamine, barium sulphate, and sodium nitrate. O. S. E.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

A FURNACE WITH AUTOMATIC STOKER, TRAVELLING GRATE, AND VARIABLE BLAST, INTENDED ESPECIALLY FOR BURNING SMALL ANTHRACITE COALS.

By Eckley B. Coxe. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxii.*, *pages* 581-606.

The difficulties of burning small sizes of anthracite coal are such that large quantities of such fuel have in the past been thrown away. On the formation of a Commission by the Legislature of Pennsylvania for the purpose of investigating the "Waste of Coal Mining," attention was directed to the most economical method of burning small sizes (from $\frac{6}{10}$ to $\frac{3}{16}$ inch diameter) of anthracite coal, and as an outcome of experiments carried out at Drifton, the furnace and stoker herewith described was designed by Mr. Coxe. In a general way it may be said that the proper conditions required to be fulfilled were: (*a*) To ignite the coal, and burn it up without mixing it with fresh fuel, that is, that fresh fuel would not be added to the already partially consumed coal. (*b*) To have the furnace so arranged that the combustion would be continuous and uniform.

The furnace consists essentially of a travelling grate, moving at the rate of from 3½ to 5 feet per hour to the back of the furnace. The coal is brought to a feed-hopper, and passes down by gravity over a fire-brick, called the "ignition brick," and under a regulating-gate, on to the travelling-grate. When the furnace is heated, the ignition-brick becomes hot, and the coal passing over it reaches an incandescent state, often becoming hot enough to ignite before passing on to the grate. Under the grate are a number of air-chambers, made of sheet-iron, which are closed on all sides except the top. Blast from a fan is blown into the second air-chamber from the right. The air-chambers are open on the top, but the partitions between are covered by plates of such a width, that no matter what may be the position of the grate-bars, there is always one resting on the plate. Consequently, air cannot pass from one chamber to the other except by leakage along the bar. The consequence is that the air-pressure in each successive chamber is smaller than in the adjoining one, passing from the front to the back of the furnace.

As the thoroughly ignited coal passes slowly over the second compartment (where the air-pressure is at a maximum) it burns briskly; then slowly passing over the third compartment, where the air-pressure is less, and better suited to the combustion of the thinner layer of partially consumed coal, the bed continues to diminish in carbon, and to be subjected to less blast, until finally the hot ashes are cooled off by a very gentle current of air. H. W. H.

COAL-DUST QUESTION IN ENGLAND.

Note sur la question des Poussières en Angleterre. *By* L. Aguillon. *Annales des Mines*, 1895, *series* 9, *vol. vii.*, *pages* 535-559.

The author confines himself to the consideration of the results of the Royal Commission on Explosions from Coal-dust.

The commission undertook the consideration of recent large accidents which had been by some attributed to coal-dust. They examined on the spot four explosions which occurred while they were sitting, and directed new experiments on coal-dust to be made by Mr. H. Hall.

The conclusions of the commission are said not to be such as to impress opponents of the coal-dust theory. The only new elements that they had to consider were the experiments of Mr. Hall, which the author thinks differed little, so far as concerns the rational and definitive solution of the question, from the experiments made by the Prussian Commission at Neunkirchen.

The conclusions of the commission are said to resemble the decision of an arbitrator who decides on the evidence of opposing witnesses. Scientific questions cannot be decided in this way. The author thinks that the divergence of opinion between the supporters and opponents of the coal-dust theory may be more apparent than real, because they do not appreciate the difference between inflammation and explosion.

The observations and conclusions of the commission are then set forth and commented on. With reference to the distance traversed by some explosions, an account by the author of the explosion at Seaham in 1880 is referred to, and it is stated that the flame in that explosion only exercised action within a very restricted area. [This is an incorrect statement, probably based on imperfect information.—Editor.]

With reference to the lack of indications of violence for some distance on each side of shots to which certain explosions were attributed, it is remarked that the commission appear to have forgotten the experiments of Messrs. Mallard and Le Chatelier on gas explosions in tubes and the difference of the effects according to the point of inflammation in the tube. [The commissioners do not state the most important conclusion drawn from the spaces free from violence with great damage on each side; such conclusion did not relate to the question of gas *versus* coal-dust, but was simply that they indicated the place where the explosions commenced, and there is nothing in the experiments of Messrs. Mallard and Le Chatelier opposed to this conclusion.—Editor.]

The appendices contain accounts of the accidents at Brandon and Camerton collieries and of Mr. Hall's experiments. It is doubted whether these experiments produced explosions as opposed to inflammations, and they are held not to authorize the deduction that the inflammation or explosion would continue indefinitely.

W. N. A.

COPPER-MINING IN TENNESSEE, U.S.A.

Ducktown, Tennessee, Copper-mining District. *By* Wm. M. Brewer. *Engineering and Mining Journal (New York)*, 1895, *vol. lix.*, *page* 271, *with one figure.*

The Ducktown district is situated in the extreme south-eastern corner of Tennessee, and within a very short distance of the meeting point of the three states of Tennessee, Georgia, and North Carolina. The district is bounded on the east by the Blue Ridge mountains, on the west by the Smoky range, with Frog mountain near the south-western extremity. The Ducktown Copper, Sulphur

and Iron Company four years ago purchased the copper-mining property originally owned by the Union Consolidated Mining Company. The last-named company, several years ago, mined out a body of black copper ore, which occurred underlying the gossan, and it is the purpose of the present company to commence underground explorations in order to ascertain the extent of the body of unaltered pyrites, which is expected to occur below the gossan. The new company is prospecting on the Callaway estate, and extracting ore from the Mary mine, which furnishes the supply for the furnaces.

On the 20-fathoms level in the Mary mine, from which this ore is being mined, the workings show in many places the body of unaltered pyrites to be 90 feet in thickness. This ore carries an average of about 3½ per cent. of copper and 27 per cent. of sulphur, with no arsenic or other injurious element. Consequently the matte from the first smelting is very clean, and averages 46 per cent. of copper, a most unusual proportion to be contained in the matte after the first smelting from an ore of so low a grade. During the four years that the present company has been in operation it has done much experimental work, under the superintendence of Mr. T. Carter, formerly of Shropshire, England.

Sixty shelf pyrites-burners for roasting ore were erected, with a capacity of 3,000 pounds each per day, and arranged with six shelves in each furnace, 6 feet by 10 feet. Each charge of fine pyrites now requires 48 hours. J. W.

THE DOLGOROUKY COPPER MINES, RUSSIA.

ANON. *Indian Engineering*, 1895, *vol. xvii.*, *pages* 44-45.

The Dolgorouky mines are situated on the Steppe in the districts of Boulinsk and Bourlinsk, some 65 miles south of the town of Orenburg. The mineral rights belong to the Russian Government, which has the power to grant concessions for mining; otherwise the great mineral wealth of the country would remain undeveloped, the native Khirghiz being a very superstitious race.

The rocks are chiefly of Permian age, well stratified. The ores are oxidized compounds of copper, the green and blue carbonates, usually termed malachite and azurite, with small agglomerations of copper-glance in places.

At Kisul-Bei mine the average yield of copper is 10·1 per cent., the bed having a thickness of from 1½ feet to 2½ feet. At Kouchouk-Bei, the bed is about the same thickness, the yield being only 4·5 per cent. of copper. At the Cir-Koul mine, ore varying from 10·5 to 21·5 per cent. of copper has been removed.

Complete analyses of the ore show :—

	Cir-Koul.	Kisil Adeur.
Copper oxide	13·13 ...	10·41
Ferric oxide	10·72 ...	18·71
Carbon dioxide	1·36 ...	3·27
Water of combination	3·89 ...	1·50
Silica	71·00 ...	66·07
Totals	100·10 ...	99·96

The ores from all the mines are similar as regards their freedom from injurious elements, only a trace of sulphur being present and arsenic being absent. No expensive roasting is required; in a single fusion metallic copper can be obtained. The cost of mining and transport to furnace is about 15s. per ton, and the cost of treatment is about the same. J. W.

ELECTRIC HAULAGE AND SIGNALLING.

The Engineering and Mining Journal (*New York*), 1895, *vol. lix., page* 33, *with two illustrations.*

The Western electric locomotive is waterproof, has two slow-speed motors connected in parallel, each motor operating an axle by a single reduction with cut gears. Armatures are ring-wound, thus permitting the removal of a coil without tearing the whole armature to pieces. In the machine illustrated, the weight will guarantee a haulage of 75 tons without slipping its wheels on a straight level track. The dimensions of the locomotive are :—Length, 8½ feet ; width over all, 54¾ inches; height above rail, 45 inches; weight, 15,600 lbs. ; width of gauge, 36 inches.

The Western signal bell is a positive stroke gong, simply constructed, has no winding mechanism, and is non-vibrating. No mistakes can be made by the engineer, as only one blow can be struck for each complete turn of the handle, and the handle cannot be moved backward to ring the gong. One bell will suffice for several levels, but a separate switch is required on each level. J. W.

A NEW ELECTRIC MINE HOIST.

Anon. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix., page* 201, *with illustration.*

An electric hoist has been erected at the Priceburg mine, at Dickson, Lackawanna county, Pennsylvania. It forms part of a complete electric plant being placed at the mine, including an 80 horse-power electric locomotive and a 100 kilowatts generator. The hoist has two motors, the advantages of which arrangement are fully explained ; it is a hoist of the friction type, having internal friction-gear. It is to be used from the upper end of the slope, for hauling cars out of the butt entries into the main entry and lowering them down to the level track, where they will be made up in trips for the locomotive to haul out to the shaft. The advantage of this arrangement becomes more apparent when it is considered that the hoist is to be placed 5,000 feet from the power-house upon the side of a mountain, where it would be practically impossible to use a steam plant, as there is no water to be had conveniently, and it would be difficult and expensive to carry coal for firing the boilers. J. W.

THE GENESIS OF ORE-DEPOSITS.

By F. Posepný. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii., pages* 197-368 *and page* 587.

The author of this exhaustive paper begins by briefly summarizing the various systems of classification employed up to the present time, and comes to the conclusion that a stable and complete system can only be framed when all the controlling facts—in other words, all the ore-deposits—are accurately known. This is not likely ever to be the case. New observations are being constantly made in mining, and these often obliterate the old ones, so that they cannot be verified and compared. It is, however, absolutely necessary, in a field so complicated as that of ore-deposits, to have some general system, comprising all known results.

In framing such a system, the characters of form being the most obvious and the most familiar to the miner would be naturally emphasized, while genetic characters would be left in the background. But this ought not to check genetic investigation, or the advancing recognition of real relations.

A genetic system must involve hypotheses, and may not, for a while, be practically useful; but in time it will, like every other cultivated branch of geology, assume more permanent forms.

The principal genetic distinction is doubtless between deposits contemporaneous with the country-rock and those subsequently formed in it.

There are two main groups of mineral aggregates--(1) rocks; and (2) mineral deposits.

The minerals of the first group belong to it as native and original, and may be designated as idiogenous. Those of the second group are foreign to the rocks in which they occur, and may be designated as xenogenous.

If we find in the midst of stratified formations ores lying exactly between two strata it is not conclusive proof of their sedimentary or precipitative origin. This must be proved in every given case, for in the present state of knowledge we cannot understand how the metallic sulphides, so characteristic of ore-deposits, could be formed in that way.

As to the eruptive rocks, we do not know what they once were, for we study them only from the moment of cooling. But we observe at once that iron occurs primitively in these rocks in the form of magnetite. This idiogenite of the eruptive rocks can be detected without chemical aid; but with such aid we find traces of other metals, and this leads us to surmise that the eruptives have brought a whole series of heavy metals from the barysphere into the lithosphere, and it looks as if the metals of the ore-deposits originally belonged to the barysphere.

With regard to the mineral deposits or xenogenites, it is apparent that they must either have found a space ready to receive them or have made room by driving out an original mineral. We know that small pores or cavities exist in substances of the greatest density, since we can, by adequate pressure, force quicksilver through them. Moreover, we find larger cavities or blow-holes in the eruptive rocks.

Mineral deposits formed upon the walls of cavities by liquids circulating within them usually have a characteristic structure, for which the term "crustification" is proposed. These crusts generally occur concentrically in regular succession, covering not only the cavity-walls, but the surface of every foreign body in the cavity. Sometimes the crusts have undergone a secondary alteration (carbonates are replaced with silica, etc.). The crustification is thus made less distinct, or is even obliterated. As a general rule, however, crustification is a characteristic feature of cavity-filling.

The cavities are formed either by mechanical forces, called spaces of dislocation or discission, or by chemical forces called spaces of corrosion or dissolution, and these two must be sharply distinguished.

Spaces of dissolution naturally occur in soluble rocks. We must assume that the liquid which formed the space of dissolution also performed the filling, in fact, that both processes were almost contemporaneous. They must not, however, be confounded with the metamorphic processes, where the idiogenite is expelled, atom by atom, by the xenogenite, for the deposits in spaces of dissolution always show a distinct crustification, hence every single crust must have found a free space waiting for it.

Concerning the origin of spaces of discission, two groups are distinguished--those which do not extend beyond one rock, and where the force which produced them probably has its seat in that rock; and those which extend out of one rock into another, the force which produced them residing outside of the formation.

As to the filling of spaces of discission, they do not represent open spaces of uniform width throughout, for the original fissure was sometimes closed by detritus

formed by the friction of the walls, or by the movement of the country-rock and other causes. Only the places remaining open would permit an active circulation of solutions and a regular deposition from them. When high pressure was present and the rock contained interstices, the liquid doubtless penetrated into the rock, impregnating it with mineral; or a soluble rock was attacked, and spaces of dissolution formed and filled in like manner as the fissure itself. This explains the fact that, in the same vein-plane, rich deposits alternate with poor or barren spots. Where the mineral solutions formed no cavity they must have expelled part of the original material, and to do this they must have had free access, such as might be furnished by original rock-cavities or by secondary cavities.

After the expulsion of the original material the resulting deposit must be massive, showing no crustification. Frequently, however, there are only negative indications of the metamorphosis. It can merely be seen that the deposit is not an original rock, or that it has not been deposited in pre-existing cavities, and hence that it must have been formed by replacement.

There are two kinds of metamorphous-deposits. In the first, the new material has replaced the more soluble ingredients of a heterogeneous rock, and the result resembles an impregnation. In the second, a homogeneous rock has suffered metamorphosis, and the deposit resembles filled cavities of dissolution.

The author then describes the vadose or shallow underground circulation, pointing out how a siphon-action may be set up and the ground-water of one region find a distant outlet.

It is often possible to observe directly, not only the formation but also the filling of these cavities, and thus to obtain valuable material for the explanation of the origin of xenogenites outside the vadose circulation, and not observable in the stages of formation. It is a most important fact that the phenomena of leaching indicate the path of the circulating liquids through soluble rocks, so that we can study the process in its several stages. A good example of the formation of paths of circulation by leaching action is to be found at the Máros Ujvár salt-mines of Transylvania. The filling of open spaces formed by the vadose circulation is important genetically, since it can be directly observed, and furnishes many conclusions applicable to inaccessible subterranean occurrences. The author describes the deposits formed on the walls, roof, and floor of caves, and infers that if circulating liquid fills the whole cavity the attraction of the walls for the precipitated particles is controlling; but that when air or gas enters gravity becomes predominant and draws these particles to the bottom.

In opal and chalcedony-geodes both forms of precipitate can often be seen, the crust uniformly covering the walls and the horizontal deposit.

The ground-water descends in the deep regions through the capillaries of the rocks; at a certain depth it probably moves laterally towards open conduits and ascends through them to the surface. The solvent power of the water increases with temperature and pressure, also with the duration of its underground journeying. Hence, while descending it can dissolve or precipitate only the more soluble substances. But the ascending current in open conduits is undoubtedly loaded more heavily with less soluble substances, which, as the conditions of their solubility gradually disappear in the ascent, must be deposited in the channels themselves.

These ascending currents, heated and often loaded with minerals, are constantly met with in mining. The author here describes the hot springs on the Comstock lode. The quicksilver mines at Sulphur Bank, California, are mentioned as exhibiting the formation of ore-deposits by ascending waters containing large

quantities of sulphuretted hydrogen (H_2S) and the decomposing effect of that gas—oxidized into sulphuric acid (H_2SO_4)—upon the country rock.

The most important factor in ascending waters is carbonic acid, for it is chiefly this gas which in the deep region, under high temperature and pressure, develops a greater solvent power for most of the elements of the rocks.

Minute metallic mixtures are also found in mineral springs, either dissolved in the water itself or deposited at the mouths of springs, where they are concentrated in observable quantities.

The structural features of the deposits of mineral springs, such as crustifications of wall-deposits, pisolitic forms, etc., are identical with those of ore-deposits an additional reason for declaring the latter to have been formed by mineral springs.

The author opposes the views of Dr. Sandberger, who upholds the lateral secretion-theory for the origin of ore-deposits. He thinks that the metals found in the country rock, and stated by Dr. Sandberger to be the source of the deposits, were really xenogenous—derived from the ore-deposit—and is led to this conclusion by the small quantity which can be formed in the country rock.

The various classes of ore-deposits may be divided into four groups.

(1.) Fillings of spaces of discission (fissures, etc.).

(2.) Fillings of spaces of dissolution in soluble rocks.

(3.) Metamorphous deposits in soluble rocks, in simple sediments, in crystallines and eruptives.

(4.) Hysteromorphous deposits (secondary deposits, due to surface-agencies).

The author has attempted to show that in the two regions of underground circulation the formation of ore-deposits has taken place according to different, almost opposite principles. In the vadose region through descension and lateral secretion, in the profound region by ascension, as the product of upward currents. He points out that the original sources of the metallic solutions can scarcely have been reached by mining, and that these sources must lie at still greater depths.

1. *Ore-deposits in Spaces of Discission.*—These may be further subdivided into:—

(*a*) Ore-veins in stratified rocks. Examples of this class, *i.e.*, entirely unconnected with eruptive rocks, are not easily found. The veins of Clausthal in the Harz and Andreasberg are mentioned.

(*b*) Ore-veins in the neighbourhood of eruptive masses. Examples: The Erzgebirge and Pzribram where the rich ore-ground starts from the intersection of the great structural fault with the zone of eruptive rocks, in other words, from the point relatively nearest to the barysphere. The dykes of this district present different kinds of eruptive rocks, and are generally decomposed in the neighbourhood of the ore-veins, no doubt owing to the action of the mineral springs. The stratified rocks—Cambrian sandstone—show near the granites a contact-metamorphosis which has converted them into hornstone.

(*c*) Ore-veins wholly within large eruptive formations. Examples: Hungary, the Dacian gold-field, the Comstock lode. This latter is properly a quartz-vein, in which important ore-concentrations have been formed, not showing any clear crustification (except in the Justice mine). This, however, may have been subsequently obliterated by metamorphosis of the vein-mass, *e.g.*, through the replacement of calcite by quartz, It is also a contact-vein between a diorite foot and a diabase hanging-wall. So far as the sources of the eruptive rocks can be inferred they were all (except the diorite) on the hanging-wall side of the vein, as were also the mineral springs which decomposed these rocks. But the ascending thermal waters encountered in these mines were within the vein itself; whence it

may be concluded that the ore-bearing solutions came by that road from the deep region, and not, according to the lateral-secretion theory, from the side.

The Comstock lode had always been looked upon as an example of the lateral-secretion theory, and this point was freely discussed by members of the American Institute, who seemed disinclined to give up their former opinions.

2. *Ore-deposits in Soluble Rocks.*—Examples: Rodna and Offenbánya in Transylvania, Rézbánya in south-eastern Hungary, Raibl in Carinthia, North of England lead-mines, Leadville, and Red Mountain in Colorado, Nevada, Wisconsin, etc.

3. *Metamorphous Deposits.*—Metamo phism has been defined as the sum of the chemical changes undergone by the sedimentary rocks after their deposition. There are two kinds of metamorphism, general or regional, affecting the rocks over wide areas; and local or contact-metamorphism caused in certain groups of strata by eruptive intrusions. The latter is more important in dealing with our subject. We distinguish the replacement of some constituents of a compound rock, for which the term "impregnation" is used, from the replacement of the whole homogeneous mass by metasomasis.

The metamorphous deposits are reviewed as they occur in (*a*) distinctly stratified rocks; (*b*) soluble precipitates; and (*c*) crystalline schists and eruptive rocks.

(*a*) Metamorphous deposits in distinctly stratified rocks. Some authorities are inclined to believe in the deposition of ores from sea and fresh water. The author has, however, never been able to find genuine ore-beds among rocks deposited by salt or fresh waters, but always only ores of a subsequent introduction, and therefore believes that such ore-beds proper do not exist. Examples: the kupferschiefer of Mansfield, where the clearly defined influence of faults upon the ore-distribution points to a later introduction of ore through the fault-fissures. The copper-bearing veins of Westphalia; copper sandstones of Bohemia and St. Avold; the lead-deposit of Mechernich; Silver Reef in Utah; copper-deposits of New Mexico and Lower California.

(*b*) Metasomatic deposits in soluble rocks. A metasomatic replacement of the original rock-material was clearly proved long ago for some instances, *e.g.*, calamine-deposits, while in other cases, where proof has not been obtained, analogies in the observed circumstances speak for such an origin. Examples: the calamine-deposits of Raibl in Carinthia, Weisloch, Vieille Montagne, and of Laurium in Greece, the limonite-deposits of Cumberland, etc.

(*c*) Deposits in crystalline schists and eruptive rocks. As a general rule, in regional metamorphosis, the older a rock is the more changes it will have been found to have undergone. Yet these changes do not advance in all places uniformly. The action of mineral solutions upon the country-rock of some veins might also be classed as impregnations. As examples of this the author describes some of the Cornish tin capels. The ore-deposits in metamorphous and eruptive rocks occur especially in the great crystalline northern areas, in Scandinavia, Canada, and the north-eastern United States. The zinc-blende mine of Åmmeberg is cited as being of particular interest.

The copper district of Lake Superior offers a number of very interesting occurrences, some of which have not yet been satisfactorily explained. The author is inclined to believe as the cause of the first ore-depositions, the action of hot springs long after the intrusion of the eruptive flows between the sedimentary strata, so that the ores were brought not by or in the eruptives themselves, but by the later springs from great depths and perhaps from considerable distances.

4. *Hysteromorphous (or later-formed) Deposits.*—These comprise:—

(*a*) Chemical effects. On the surface it is especially the oxidizing effect of the atmosphere, the carbonic acid it contains, and the solvent and chloridizing action

of atmospheric precipitation aided by wind and moving water. Example: the limonite-deposit near Rio Tinto. Mine-waters contain the solutions of all substances directly or indirectly dissolved by the vadose circulation, and some of these, encountering suitable precipitants, may be thrown down. These new precipitates will mark the track of the mine-waters. Solutions formed by surface-waters, like those of the mine-waters, mostly find their way to the points where the water-level reaches the surface, yet they may produce impregnations in the deep region by penetrating to greater depths. The decomposition above water-level of gold and silver-bearing deposits facilitates the extraction of these metals.

(*b*) Mechanical effects. Grouped under the head of erosion. Surface-deposits *in situ*. If an ore-deposit, by reason of its greater resistance, crops out above the level of the country, the wind will continually tend to blow away the finer and lighter portions of the detritus formed by chemical weathering; so that in course of time only the heavier portions of the original outcrop will remain. The great agent in the transportation and redeposition of the metallic portions of original deposits has unquestionably been flowing water. With regard to the concentration of these metallic portions, the author believes that the most probable explanation may be based on the principle that the specifically heavier elements of a loose mass are able, with the aid of water, to work their way down through the lighter portions, and thus become concentrated on the bed-rock stream-detritus.

The detrital deposits produced by running water are characterized by the predominance of permeable material, such as sand, gravel, etc. Under this covering mass lies the solid impermeable "bed-rock," and in all the gold-fields of the world the richest pay-deposits are found, as a rule, at the border between the cover and the bed-rock. If the latter is decomposed, fissured, or otherwise loosened, the fine gold will sink into it, making it sometimes rich enough to be mined and concentrated.

Marine detritus. In some regions, the auriferous detritus, after being repeatedly deposited and again swept away, has at last reached the sea. Here the ebb and flow of the tide operate very nearly on the principles of artificial ore-dressing, and one would expect to find a concentration of the heavier particles: but this effect has not been recognized hitherto.

Platinum and tin placers are also given as examples of hysteromorphous deposits.

(*c*) Hysteromorphous deposits of the older geological formations. Examples: Deadwood, Dakota, where the conglomerate of pebbles of quartz, schist, and hæmatite, which lie at the base of the Cambrian series, carry partly coarse gold under such circumstances that there can be no doubt of its secondary origin; the Witwatersrand conglomerate in the Transvaal, which is of Palæozoic age; and in Bohemia, where considerable traces exist of ancient placer-mining in old Permian and Carboniferous conglomerates. A. W. G.

GOLD IN THE HIGHLANDS OF BRAZIL.

By J. C. Branner. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix., page* 55.

Brazil was at one time the greatest gold-producing country in the world, and it was, until recent years, also the greatest diamond-producing country. The yield of gold and diamonds was at its height while African slaves were still being shipped into the country in large numbers. When the traffic was stopped the price of slaves went up, and many of the mines ceased work for want of cheap labour.

Most of the mining in Brazil for the last forty years has been by *garimpeiros*, *i.e.*, single prospectors washing the pockets of sand and gravel in the beds of streams.

Dr. Eugene Hussak says: —"For more than 150 years gold has been mined in Goyaz, and though mining is almost extinct, being confined to a few hundred *garimpeiros* using the most primitive methods, it is certain that its auriferous wealth is not exhausted."

According to Dr. Arena a cubic metre of rock yields one milreis (4s. 6d.) worth of gold, enough to pay a properly directed hydraulic system employing amalgamation. It is evident that batea-work in such a place cannot pay expenses.

J. W.

A BROMO-CYANIDE PROCESS FOR GOLD EXTRACTION.

By C. A. Mulholland. *The Engineering and Mining Journal (New York)*, 1895, *vol. lix., page* 510.

The bromo-cyanide process is not patented, and is offered to the attention of the mining industry by the author. It differs from the Sulman-Vautin process in that cyanogen bromide is employed by them, whereas free bromine is used by Mr. Mulholland.

The results in most cases were good, and sometimes very good, reaching an extraction of 97 per cent. in a period of time impossible with existing methods.

The following reaction is said to take place:—

$$4\,Au + 8\,KCy + 2\,Br + O_2 + H_2O = 4\,KAuCy_2 + 2\,KBrO_3 + 2\,KOH.$$

The bromine is applied in various ways; the ore is kept agitated, and from time to time the bromine is admitted till the proper volume has been passed into the stuff, or the solution is allowed to percolate through the ore in the presence of the requisite amount of bromine vapour; or, finally, air and bromine in suitable proportion are blown through the ore in the leaching solution. Each of these methods is said to have its advantages.

The bromine used may be recovered again, after the gold has been precipitated with zinc, by concentrating the solution and treating it with hydrochloric acid.

The author specially recommends the process to those who have bodies of tailings, slimes, etc., which hitherto have not been deemed profitable for extraction. The process is said to be simple, rapid, and economical, giving a high percentage extraction, requiring no expensive plant or recondite chemicals, and is considered an advance on the treatment of ores by potassium cyanide solution alone.

J. W.

GOLD-MINING AT CRIPPLE CREEK, COLORADO, U.S.A.

By Arthur Lakes. *The Colliery Engineer (Pennsylvania)*, 1895, *vol. xv., pages* 121-123 *and* 145-148, *with ten illustrations.*

The author describes the Cripple Creek mining district, now one of the leading gold-regions of the Western States, dealing with its location, topography, and geology.

Descriptions are given, with drawings, of the Buena Vista, the Victor, Deer Horn, Anaconda, Ida May, Elkton, Moose, and Independence mines.

Professor Lakes concludes by recommending prospectors to search, first, for the "float rock," or broken off portions of the vein-matter, washing by "panning," if necessary; then, if particles of gold are found, trenching should be proceeded with higher up the hill.

J. W.

GOLD EXPORTED FROM WESTERN AUSTRALIA.

Return of gold, the produce of the Colony, entered for export from 1st January, 1886, to 31st December, 1894; showing quantity and value* obtained from respective gold-fields, etc.—*Government Gazette*, January 19th, 1895.

Year.	Kimberley.		Pilbarra.		†Yilgarn.		Ashburton.		Murchison.		Dundas.		Totals.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	O. D. G.	£ s. d.	O. D. G.	£ s. d.	O. D. G.	£ s. d.	O. D. G.	£ s. d.	O. D. G.	£ s. d.	O. D. G.	£ s. d.	O. D. G.	£ s. d
1886	302 0 0	1,147 12 0	..	..	..	..	..	..	..	..	..	..	302 0 0	1,147 12 0
1887	4,873 0 0	18,517 8 0	..	..	..	..	..	..	..	..	..	..	4,873 0 0	18,517 8 0
1888	3,493 0 0	13,273 8 0	..	..	..	..	..	..	..	..	..	..	3,493 0 0	13,273 8 0
1889	2,464 0 0	9,363 4 0	11,170 0 0	42,446 0 0	1,858 10 0	7,062 6 0	..	..	..	..	..	..	15,492 10 0	58,871 10 0
1890	4,474 0 0	17,001 4 0	16,055 6 6	61,010 3 9	2,277 0 0	8,652 12 0	..	..	..	..	..	..	22,806 6 6	86,663 19 9
1891	2,699 12 8	10,258 10 10	11,875 0 0	45,125 0 0	12,833 5 23	48,766 10 8	838 14 10	3,187 2 9	2,064 8 16	7,844 16 11	..	..	30,311 1 9	115,182 1 2
1892	1,058 16 22	4,137 12 3	12,892 16 0	48,992 12 10	21,209 9 18	80,596 1 1	0 14 0	2 13 2	24,356 9 12	92,554 12 1	..	..	59,548 6 4	226,283 11 5
1893	1,021 13 23	6,162 9 0	11,638 10 0	44,454 6 0	75,744 10 23	287,829 5 8	457 14 22	1,777 8 8	21,210 8 22	80,599 13 11	147 19 11	562 5 11	110,830 18 5	421,385 9 2
1894	588 12 17	2,236 16 4	16,254 10 0	61,767 2 0	136,828 4 4	519,947 3 9	285 5 10	1,084 0 8	52,946 6 11	201,196 0 7	228 7 12	867 16 6	207,131 6 6	787,093 19 10
Total	21,604 15 22	82,098 4 5	79,946 2 6	303,795 4 7	250,751 0 20	952,853 19 2	1,592 8 18	6,051 5 3	100,577 13 13	382,195 3 6	376 6 23	1,430 2 5	454,848 8 6	1,724,423 19 4

* The Official Valuation is £3 16s. per oz.

† Including for 1894, Coolgardie, viz., 105,329 ozs. 16 dwts. 11 grs., of the value of £400,253 6s. 8d.

M. W. B.

CYANIDING *VERSUS* CHLORINATION FOR GOLD ORES.

Cyaniding or Chlorination. *By* E. A. Schneider. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix.*, *page* 461.

The author having had excellent opportunities, recently, of investigating the working of the cyanide and chlorination extraction-methods in the Western States of America, discusses their respective advantages from an unbiassed standpoint.

He is of opinion that under exceptionally favourable conditions the cyanide is cheaper than the chlorination process; but under all circumstances it is safer to operate chlorination-works. Chlorination can be successfully applied to almost any gold ore, whereas the cyanide process gives satisfactory results with only a certain class of ores.

In such localities as Cripple Creek, where the character of the ores is liable to change from day to day, the cyanide process is considered risky; it also requires, in most cases, extremely skilled chemical supervision. On the other hand, the chemical part of the chlorination process is very simple. J. W.

TREATMENT OF ORES IN THE COONEY MINING DISTRICT, NEW MEXICO, U.S.A.

By Carl Andersen. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix.*, *page* 388.

Mills, where pan amalgamation is used, have been erected at five different mines. The ore, after sorting, has averaged from 6 to 8 dollars in gold, and from 10 to 12 dollars in silver. The extraction varies from 65 to 75 per cent. of assay value, 70 per cent. being an average. The ores are pulverized to 40 mesh, no grinding being done in the pans. From 1·5 to 3 pounds of copper sulphate, and from 10 to 30 pounds of salt are used per ton of ore. The best results have been obtained by treating the pan until steam commenced to escape. The loss of mercury is about ¾ pound per ton, when the charge is carefully settled; but this loss is sometimes greatly increased, by bunches of ore carrying oxide of manganese, which causes the mercury to flour. Great loss has often been caused by millmen not understanding the reaction of the chemicals that they use on the ore treated; of this the author gives a notable instance.

Numerous laboratory experiments, conducted by the author, gave an extraction with cyanide, at 30 mesh, of 90 per cent. of the gold and 80 per cent. of the silver, the loss of potassium cyanide, when using ½ per cent. of lime, being only 1 pound per ton.

The cost of mining and sorting at these mines averages between 4 and 5 dollars per ton. Cost of milling: wages, 2½ dollars; wood, 90 cents; and chemicals, 90 cents; total, 4·30 dollars per ton. J. W.

THE CYANIDE PROCESS FOR GOLD EXTRACTION IN VICTORIA.

The Cyanide Process in Victoria. *By* Henry Buckley. *The Engineering and Mining Journal (New York)*, 1895, *vol. lix.*, *page* 582.

The author watched the cyanide process working at the New Golden Mountain mine, Bonnie Doon, Victoria. The plant erected consists of 3 leaching-vats, 18 feet in diameter and 5 feet deep, and 40 tons capacity; also 2 solution-vats, 16 feet in diameter and 5 feet deep, a dissolving-vat, and 2 zinc or precipitating-boxes.

The ore is treated by crushing, dry, in a pair of Cornish rolls, a little lime being added to correct acidity; then through a hopper and Faucett mill, with $\frac{3}{16}$ inch perforated grate, and finally through a pair of Krom rolls into the storage-hopper.

The ground ore being placed in the vat, the cyanide solution is run on. In due time the solution is allowed to pass through the zinc in the precipitating-boxes. When the solution has disappeared under the ore, a washing of water is run on, followed by a second washing, to remove all the cyanide. When the treatment is completed, the zinc is removed and dissolved in sulphuric acid; the residue is washed on a calico filter, dried, heated strongly to oxidize the baser metals, and the resulting mass is smelted in a plumbago crucible with borax and sand, the slags being again treated to free them from adhering beads of gold.

The average percentage of gold extracted by the cyanide was 82·3 per cent. of total contents. The cost of treatment per ton of ore is:—Potassium cyanide, 4s. 7d.; zinc shavings, 2$\frac{3}{4}$d.; lime, 3d.; cost of labour, filling and discharging vats, etc., 5 d.; total, 5s. 6d. J. W.

THE LIMITATIONS OF THE GOLD STAMP-MILL.

By T. A. Rickard. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii., pages* 137-147.

The author compares the stamps in use in Colorado with those of California. In the former, the stamp weighs 550 to 600 pounds, falls a height of 18 to 20 inches, and crushes about 1 ton per twenty-four hours. In the latter, the stamp weighs 750 to 850 pounds, falls only 4 to 6 inches, and will crush about 2$\frac{1}{2}$ tons per twenty-four hours. Yet each stamp is the best suited to the ore it has to deal with The action of water and bubbles of air in the mortars are fully described, also the method of collecting the fine gold on amalgamated plates.

The author contrasts the methods employed in olden times with those of the present day, and concludes that though the appliances of to-day may show a great advance upon the older and more imperfect type from which they were evolved, yet there is no mining district that possesses a mill which cannot, in some essential, be improved. A. W. G.

IRON PYRITES IN MASSACHUSETTS, U.S.A.

Sulphur Mining. By E. McCormick. *The Colliery Engineer* (*Pennsylvania*), 1895, *vol. xv., pages* 243-244.

In the western parts of Massachusetts is the largest deposit of pyrites known in the United States. The mining town called Davis has sprung up around these workings. The mines were first opened in 1881. The Davis Sulphur Ore Co. are the only producers in the State; their pyrites contains from 50 to 51 per cent. of sulphur, and is said to be quite free from arsenic. An analysis of the ore shows:—

Sulphur, 51; iron, 45·75; copper, 1·5; and silica, 1·7 per cent.

The vein varies in thickness from 12 to 45 feet, and the lower workings are said to yield the same grade of ore as did the first opening of the mine.

In mining, a shaft 60 feet deep is sunk, a pillar 20 by 60 feet being left; a drift is driven along the vein to the next shaft, and a shaft sunk again to the next level.

The ore is screened and divided into lump ore and wet smalls. The pyrites is extensively used for the manufacture of sulphuric acid. J. W.

A NEW IRONWORKS IN THE URAL.

Ein neues Hüttenwerk im Ural. *By* A. Mestchersky. *Stahl und Eisen*, 1895, *page* 483.

One of the consequences of the building of the great Siberian railway has been the starting of a number of undertakings for the manufacture of iron, among them the rail-rolling mills of Bogoslowsk in the Ural (province of Perm), owned by Mrs. N. M. Polowzeff. The district contains a quantity of iron-ore, and the large forest on the same estate ensures a plentiful supply of fuel for many years, while easy communication with the interior of Siberia exists *vid* the navigable rivers tributary to the Irtish and Obi.

For treating the ore—which is a red ironstone containing 90 per cent. of ferric oxide (Fe_2O_3), about $3\frac{1}{2}$ per cent. of silica (SiO_2), $\frac{1}{2}$ per cent. of lime and magnesia, and 0·04 per cent. of phosphorus—there are four charcoal smelting-furnaces of 4,500 cubic feet (125 cubic metres) capacity, equal to a daily output of 30 to 35 tons of pig iron, fitted with six Cowper blast-heaters. Four 15-tons Siemens-Martin furnaces, with wood and turf generators, travelling steam-cranes, hydraulic lifters and cranes for loading the ingots into trucks, are provided for the production of steel.

The ingots are of $1\frac{1}{2}$ tons (1,500 kilogrammes) each, rolled into six-rail lengths after re-heating in the 4 rolling-furnaces; all the operations connected with the transfer of the ingots, the adjustment of the rollers, etc., are accomplished by hydraulic power. After the first rolling and cutting in half by the shears, each of the halves is reheated in a Siemens furnace and rolled out to a 3-rail length in a triple Erdmann rolling-mill with rollers 30 inches (750 millimetres) in diameter. The engine driving this mill has a cylinder 50 inches (1·25 metres) in diameter, 5 feet (1·5 metres) stroke, and the fly-wheel weighs 60 tons. Two pendulum saws, 3 double straightening presses, and 4 milling machines are employed in the finishing process. There are sixteen boilers (water-tube) fed from a water-tower supplied from the river, some 1,500 feet away, by a pair of pumps raising 132,000 gallons (600 cubic metres) per diem.

For the supply of fire-resisting materials a factory calculated to produce about 1,000,000 bricks a year has been erected, and there is also in contemplation the establishment of a foundry with 3 cupola-furnaces, 4 revolving-cranes, and 1 travelling-crane, together with a number of special and ordinary tool-making machines.

Some 3,000 men were employed in erecting the works, which was done solely by Russian labour, but nearly all the machinery was supplied by German or French firms. With the 120 houses for married and 20 barracks for unmarried labourers, and the dwellings for the officials, the new establishment forms quite a little town. In view of its isolated position a year's stock of corn and forage has to be kept in hand. C. S.

THE MINING LAWS OF TURKEY.

La Turquie, Constantinople, 1888.

[The following digest of the mining laws of Turkey is made from a French translation of the mining Act, which appeared in *La Turquie*, of Constantinople, in 1888. The requirements of the law are, however, very loosely observed in practice. Reform is urgently needed, as the country has splendid mineral resources, and their development would add enormously to the revenues of the country, which are by no means in a flourishing state. What is most required at the present time is a

proper survey of the country, and the enforcement of the regulations for obtaining a *firman* or title without unnecessary delay or expense. The foreigner at present has, in spite of the law, endless trouble and difficulty in obtaining a *firman*, and, as a rule, only succeeds by the interest of high officials and a large expenditure of *backsheesh*. Even when the *firman* has been obtained he is very likely to be involved in litigation on the subject of boundaries, owing to the absence of reliable maps.—EDITOR.]

Chapter 1 (*Arts.* 1-3).—*Classification of Mines.*

For the purpose of this Act mines are divided into three classes :—

1. Mines with underground workings (mines).
2. Surface mines (minières), embracing iron ore deposits, turf mines, etc.
3. Quarries (carrières). These do not come under the present Act, but have their own special code of regulations.

Chapter 2 (*Arts.* 4-8).—*Generalities.*

No mine may be worked without a *permis* or *iradé impérial* (*firman*). The term of a concession is usually 99 years, but mass mines, such as chromite, emery, boracite, etc., may have a longer or shorter concession, but never less than for 40 years. The plant, machinery, horses working underground, instruments, etc., cannot be seized for debt, or the stores of one year ; but the ore at grass and the shares or profits of a company can be taken. On freehold land (*mulk*) and on endowed lands, *i.e.*, lands belonging to the mosques (*vakouf*), mines may be worked ; but one-fifth of the dues only go to the mining administration, the other four-fifths going to the proprietor of the *mulk* or *vakouf* land.

Chapter 3 (*Arts.* 9-22).—*Discovery of Mines.*

This chapter provides for mining exploration. The owner of the soil can mine without special permission, but must give notice to the administration of his intention, and must say what the mineral is. On public lands permission must first be obtained from the Government. Permission will not be given to mine on land near towns where the workings would interfere with the interests of the inhabitants. No one can explore enclosed land without permission of the surface-owner, but if permission is refused, application may be made to the governor-general of the province, with full particulars of the mine and of the land, and an undertaking to make good all damage. If this petition is made by a company, such company must be one recognized by the Government. The petition will be registered and examined by the administrative council of the province. If approved, permission to mine may be granted for one year, renewable for a second year. The permission (*permis*) may be sold, but no mineral can be sold without the express permission of the mining administration. Anyone breaking this rule is liable to a fine of from £*t*25 to £*t*100 and loss of the *permis*, and double dues will be levied on any ore sold. The holder of a *permis* may send a trial shipment of the ore to Europe once only, but the weight must not exceed 100 tons. Dues must be paid according to the nature of the ore, the value being calculated from the price-lists of Europe, and deductions being allowed for cost of freight.

Chapter 4 (*Arts.* 23-39).—*Conditions of Holding and Working Mining Concessions.*

This chapter deals with the regulations for obtaining and holding a concession (*firman*), and for working the same. Concessions may be held by foreigners as well as Ottoman subjects. No *firman* will be granted till the following points have

been settled :—(1) That the mine discovered can be worked ; (2) that the working of the mine will not interfere with the working of an adjoining mine ; (3) that the mining works will not interfere with any fortifications.

In the event of the first discoverer having failed to comply with the regulations laid down for acquisition of a *permis*, the mining administration may grant the concession to another ; but compensation will be granted to the first discoverer according to the work done, and a maximum indemnity of half a Turkish *lira* per day, and 5 per cent. of the net produce of the mine. The amount of the indemnity is to be recorded on the *firman* of the concessionaire, and until it is paid the mine will be considered mortgaged to the first discoverer or original holder of the *permis*. Objection to the amount of the indemnity may be made before the Council of State, but the settlement of the amount need not stop the granting of the *firman*.

The holder of a *permis* or right to prospect, wishing for a concession or *firman*, must make a petition for the same to the mining administration. This petition must contain full particulars of the mine, and must state what indemnity will be paid to surface-owners. The petition must be accompained by a plan (in three copies) to the scale of 1 : 500, an engineer's report, and a sample of the ore or mineral. The mining administration will examine it, and, if in order, will place it on its register. If not in order it will be sent back to the concessionaire for correction.

If it be accepted, the particulars of the concession must be published at the expense of the concessionaire in a Turkish and a French newspaper for two months ; also on posters, and in the official journal of the *vilayet* or province. At the end of two months the governor-general of the province shall report to the mining administration whether or not objection has been raised.

All documents sent to the mining administration shall be examined by the technical department, and a report made. Then six months after the report has been made the administration can proceed to obtain a *firman* from the Sublime Porte. The *firman* will bear the signature of the Sultan. The *firman* must then be published as before, but once only.

Concessionaires may not amalgamate their concession with others without permission of the Government.

The *firman* only recognizes the mineral or minerals mentioned in the petition, and the right to mine other minerals discovered later must be obtained by a fresh *firman*. The original concessionaire has always the right to any new discovery, subject to certain recompenses being paid to the discoverer. The penalty for working a mine without a *firman*, or for extracting more than a trial 100 tons, is from £*t*100 to £*t*1,000.

The mines belonging to the State come under the same regulations as private mines, as regards boundaries, indemnities, and working conditions.

The mining administration has to publish an official list of mines abandoned, mines discovered, and mines whose concessions have been confiscated. It is authorized to lease mines to the highest bidder.

The law only recognizes mines which are registered, except those that have been worked for 99 years since the date of the present law. All others are unknown, and can be denounced.

Chapter 5 (*Arts.* 40-64).—*Rights and Obligation of Concessionaires.*

On delivery of the *firman* a payment of from £*t*50 to £*t*200 has to be made. The dues payable by a concessionaire are as follows :—(*a*) According to area of concession (so much per *djérib*) ; (*b*) according to the production. The area tax is always payable, whether the mine is worked or not, as long as the *firman* is held.

It amounts to 10 piastres (1s. 8d.) per *djérib*. On the *mulk* land and *Evkafi-sahibi* lands the payment is made to the proprietors of the soil, on common land to the Government.

The production tax varies between 1 to 5 per cent. of the value at mines in the case of copper, silver-lead, coal, and other deep mines, and 10 to 20 per cent. in the case of emery, boracite, meerschaum, and other mass mines.

Proper returns have to be made on March 1st in each year to the governor of the province. The value of the ore is arranged according to a tariff (revised every six months), and the percentage payable is fixed according to the richness of the mine by the mining administration, and such percentage is entered on the *firman*. Minerals for export are weighed at the port, and minerals treated at home at the smelting or reduction-works. The penalty for sending incorrect returns is from £*t*5 to £*t*25, and double duty on the amount not reported.

The governor-general may authorize the postponement of payment of dues for a term of two months. If not then paid, the mine may be sold, in accordance with the conditions laid down in chapter 2; and if the sale does not cover the amount of dues, the private property of the concessionaire may be seized. On completion of the *firman*, the limits of the concession are laid down on the mine plan by an engineer appointed by the mining administration. An official report is drawn up, and three copies made, one for the mines office, one for the local authorities, and one for the concessionaire.

The concessionaire must commence to work the mine within two years of the delivery of the *firman*. If he fails to do so, the concessionaire is asked in writing the cause of his not doing so. If the cause is not considered valid by the mining administration, a further six months is allowed the concessionaire, and if he then fails to work the mine the concession becomes forfeited. Right of appeal, within three months, to the Council of State is allowed. If the Council of State refuse the appeal, the withdrawal of the *firman* is publicly advertized in three newspapers of Constantinople, and in the local press.

Then follow regulations regarding the working of the mines. A capable manager must be appointed. Surface and underground plans, of a scale of 1 : 500, must be kept, under a penalty of £*t*5 to £*t*25. Mines must be inspected by Government engineers.

The mining administration settle all technical disputes between neighbouring mines. If a mineowner desires to take private property within the limits of the concession he may take it, provided he pays an indemnity of twice the value of the crop that such land would produce, and must return the land in the same condition as he found it. Concessionaires may purchase private land for mining purposes; if no agreement is come to, the concessionaire must pay twice the value assessed by the Government. With the exception of the engineer and superintendent, the employés must be all Turkish subjects. For a first offence against this regulation a fine of £*t*100 is imposed; on a second offence the concession may be confiscated.

Chapter 6 (*Arts.* 65-71).—*Inspection of Mines.*

Each *vilayet*, or province, is placed under the charge of a Government engineer, whose duty it is to see that the regulations are observed and the mines properly worked. The concessionaire is obliged to keep a medical store and a qualified doctor. Concessionaires are obliged to pay an indemnity to all those who meet with an accident or to their families. The amount of the indemnity is fixed by a tribunal. Where the accident was preventable, the concessionaire is liable to a fine of from £*t*50 to £*t*100.

Chapter 7 (*Arts.* 72-77).—*Abandonment of a Mine.*

No mine can be abandoned without the consent of the mining administration. Six months' notice must be given. The concessionaire must pay all dues to date, and must sell the plant and machinery to a new concessionaire or to the State at a valuation if required to do so.

Chapter 8 (*Art.* 78).—*Concessions granted previous to the present law.*

Such concessions are controlled by the present regulations. The dues, however, both fixed and unfixed, shall be maintained on the old tariff for ten years, after which time all mines shall come under the tariff of this Act.

Chapter 9 (*Arts.* 79-92).—*On Surface Mines.*

All surface-mines may be worked in perpetuity by the surface-owner, but only after permission has been obtained by *firman*, which costs £/4. If the surface owner of a surface-mine either does not work it himself, or abandons it after a short working, the surface-mine may be given to another person, who must pay double the value of the land and full value of the buildings, etc. All surface-mines, except on *mulk* or *vakouf* land, come under the jurisdiction of *terrains domaniaux*. During the working of the mine they shall be free from all taxes except those on production.

The demand for permission to work a surface-mine must contain full particulars as regards name of concessionaire, situation of mine, mineral worked, etc., and a plan on the scale of 1 : 500. The permission shall determine the limits and the methods of working with due regard for the security of buildings, roads, water-courses, etc., and shall fix the indemnity to be paid. It shall decide as to what water may be taken for washing the ore. Surface-mines shall be under the control of Government engineers, like deep mines. A surface-mine may not be changed into a deep mine (*i.e.*, no underground workings may be made) without a special *firman*. The concessionaire may establish smelting-works with the permission of the mining administration.

Disputes of title are decided by the administration; other disputes by the ordinary courts of justice in which, in the case of foreigners, questions of title are also decided. W. F. W.

MEERSCHAUM MINING IN TURKEY.

Anon. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix.*, *page* 464.

Rich deposits of meerschaum are found 20 miles to the south-east of Eski-Shehir, a station of the Anatolian railway. Pits from 25 feet to 120 feet deep are dug, and when the bed is struck, horizontal galleries are made; but more than two galleries are seldom to be found in one pit.

The stone as extracted is called *ham-tash* (rough block), and is soft enough to be easily cut with a knife. It is white, with a yellowish tint, and is covered with a thickness of about an inch of red clayey soil. In this state the blocks are purchased by dealers, by the bulk, the price varying from £5 to £30 per load, according to quality. Most of the finest specimens of the dried meerschaum are sent direct to Paris. It is maintained, locally, that the Eski-Shehir meerschaum is superior to that of the Crimea and also to that of Greece. J. W.

THE FLOURING AND SICKENING OF MERCURY.

By T. A. Rickard. *The Engineering and Mining Journal (New York)*, 1895, *vol. lix., pages* 460-461.

The author thinks that there is often misconception as to the meaning of the above terms; in the same way, the reactions which produce the sickening of mercury are but rarely, and then only vaguely, understood. In order to aid all in getting their ideas on the subject clarified, the author discusses at length the causes of the flouring and sickening of mercury which have come under his observation in practical work. In conclusion, he defines flouring as the minute subdivision of mercury by mechanical causes, and sickening as the rendering of such a condition permanent by the intervention of a coating of some foreign substance, effectually preventing the coalescence or reunion of the globules previously formed.

J. W.

THE HEAT-TREATMENT OF STEEL.

By H. M. Howe. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii.*, *pages* 466-541.

This paper may be regarded as a report of progress of an investigation into the influence of prior exposure to different high temperatures, under different conditions, on the properties of steel after it has been cooled completely.

Experiments on Toughening Manganese-Steel by Sudden Cooling.—The result of these experiments is given in a series of tables. The author is opposed to very violent quenching as liable to induce injurious stress. It is best to quench from a very high temperature. Slightly deferring the immersion after heating is practically harmless. Slightly retarding the cooling does but slight harm. Castings should be heated slowly. Quenching effaces the injury done by previous slow cooling. The influence of repeated quenching depends on the maximum and minimum temperatures to which the manganese-steel is subjected, also on the time taken in the reheating and cooling.

The author then turns to the retardation-points of carbon-steel, *i.e.*, the points at which the regularity of the rise and fall of temperature during the heating and cooling is broken; these points are clearly shown in graphic tables, and are called the W-change and V-change respectively.

It appears that the V-change and the W-change are the opposite phases of the same transformation, the W-change conferring the hardening property, the V-change removing it. The marked retardation which occurs at W, and which shows that some deep-seated change is occurring, does not take place unless the metal, since last rising past W, has been so far cooled as to induce the V-change, and *vice-versâ*. Neither change is instantaneous.

Prof. Osmond's theory was that sudden cooling hardens steel, not by retaining its carbon in a special hardness-giving condition, but by retaining the iron itself in a purely hypothetical, special, hard, allotropic state of B-iron. The author is not of this opinion.

The results of a series of experiments on rail, hard and soft tool, soft basic, and other steels are given, showing the influence of slow cooling from high temperatures. Briefly, heating to W has in some way a wonderful toughening effect, which is lessened if the temperature rise even very slightly above W.

A description of the double-tube-muffle furnace, with the aid of which these experiments were carried out, and some notes on thermo-electric pyrometry, conclude the paper.

A. W. G.

THE MICROSTRUCTURE OF INGOT IRON IN CAST-INGOTS.

By A. Martens. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii., pages* 37-63.

The author describes the method employed in examining the microstructure of the eight samples submitted to him, three of which were taken from Bessemer ingots, two from Thomas (basic Bessemer) ingots, and three from Martin (open hearth) ingots.

The hardness of the samples varied from soft to very hard, and the proportion of carbon from 0·06 to 0·50 per cent.

The paper is beautifully illustrated by reproductions of microphotographs of the sections taken by the author, and a description is given of each.

A. W. G.

SULPHUR IN CAST-IRON.

By W. J. Keep. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii., pages* 382-399.

The object of this paper is to dispel the superstition regarding the influence of sulphur in the fuel upon the castings produced. The author describes in detail various tests which led him to the following conclusions: that percentages of sulphur that could be retained by grey cast-iron cannot materially injure the iron, except through the increase of shrinkage. Again: the testimony is, that most of the sulphur contained in the pig-iron is lost in re-melting, and that it is impossible for carbonized iron to absorb any damaging amount of sulphur from the fuel. The higher the carbon, or the higher the silicon, the smaller will be the influence exerted by sulphur. The influence of sulphur on all cast-iron is to drive out carbon and silicon, and to increase chill; to increase shrinkage, and, as a general rule, to decrease strength. But if, in practice, sulphur will not enter such iron, we shall not have any cause to fear this tendency.

In every-day work it is sometimes found that iron which was grey when put in the cupola comes out white, with increased shrinkage and chill, and often with decreased strength. This is caused by decreased silicon, and can be remedied by an increase of silicon.

A. W. G.

A NEW PROCESS FOR THE PRODUCTION OF PIG-IRON, REFINED IRON, INGOT-METAL, AND WELD-METAL.

By A. Sattmann *and* A. Homatsch. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii., pages* 3-37.

In this process a great saving is claimed by the substitution of gaseous for solid fuel, which would be more marked in localities where suitable blast-furnace fuel does not occur near the iron ores, so that in the manufacture of pig-iron heavy transportation-charges have to be levied on the product, thus raising the cost of production very appreciably.

Briefly stated the process consists of four phases:—

1.—Heating of the ore and flux, and, if necessary, calcining the ore with gas fuel.

2.—Reduction of the ore and carburization of the resulting iron-sponge with reducing gas.

3.—Melting of the carburized iron-sponge by the direct combustion of solid fuel.

4.—Separation of the resulting pig-iron from the slag, and refining with oxidizing gases immediately after the melting, thereby producing a more or less carburized metal.

The paper is illustrated with drawings of various furnaces for intermittent and continuous working, and concludes with tables of heat-calculations and a thermal balance-sheet. A. W. G.

GENERAL AND SPECIAL OBSERVATIONS CONCERNING ORE-DRESSING.

By O. Bilharz. *Transactions of the American Institute of Mining Engineers, 1893, vol. xxii., pages* 225-236.

Although the rules laid down by Mr. Rittinger in 1867 concerning the designing of dressing-works still possess authority, some modifications, suggested by practice, may be of value at the present time. The general aim in mechanical preparation should be to secure the highest results with the simplest and yet most perfect means and arrangements, so far as those desiderata can be practically combined.

Very fine crushing should be avoided on general principles, since loss is inevitable in the treatment of slimes. Liberation of even finely disseminated minerals should proceed by successive steps.

For classification, the syphon-classifier, in its improved form, may be pronounced the most perfect apparatus. The discharge-opening consists of a slit the entire breadth of the channel, so that variation of speed in the discharge is avoided. For slimes and fine sands no objections can be offered to the use of spitzkasten.

Classification according to size of grain has been recently pronounced superfluous by Mr. Hoppe, and the English practice of jigging without preliminary sizing has received general acceptance. Where the substances differ widely in specific gravity a satisfactory result can always be achieved without careful sizing; but in materials possessing very slight differences of specific gravity, a very accurate classification by grain is necessary.

In choosing a site for the dressing-works, the question of transportation should be the main factor. Repeated handling or tipping should be avoided, and the best utilization of suitable differences of level is to be studied. The several machines should be relatively so arranged that the middlings of each can be carried forward in the shortest and simplest way to the next following manipulation. In designing modern works special weight must be laid on the securing of as much lighting surface as possible. Especially to be recommended is the use of overhead lighting.

Works for mechanical preparation may be divided into: (1) Works treating coal and bituminous substances; (2) those treating metallic substances.

The latter may be subdivided according as they perform a simple or multiplex separation, *i.e.*, the separation of several constituents.

(1) *Works for the Preparation of Coal and Bituminous Substances.*—These operate on large quantities, and the following are controlling conditions:—(*a*) Convenient delivery of crude material; (*b*) maximum simplicity and rapidity of its treatment; (*c*) maximum facility for disposing of both the valuable product and the refuse.

Coal with abundant lumps does not, as a rule, require an extensive plant, unless the coal is largely intercalated with shale. Especial weight is laid upon the production of separate sizes to meet commercial demands, hence screens have become one of the most essential features of coal preparation. Essentially, therefore, an

establishment of this kind will consist of (1) coarse screens for lumps; (2) sizing-apparatus, drums, sieves; (3) coarse jigs; (4) classifiers for small; and (5) fine jigs (felspar-washers).

(2) *Works for the Preparation of Metallic Substances.*—With simple separations, the arrangements are similar to those of a coal-washing plant. In the preparation of ores of complex composition, the material is generally tipped over screens to separate the large from the small. The former, mostly rough angular pieces, are broken in rock-breakers, and a portion goes to the hand-sorting tables, while the smaller pieces, together with the smalls from the mine, are delivered to rock-jigs. Jigging gives concentrates and middle products, the latter being crushed or stamped, followed by classification and fine jigging.

With ores containing free gold, reduction in stamp-mills to fine sand and flour is generally necessary. The escaping pulp passes first over amalgamating-plates, thence to the amalgamators.

With ores containing combined gold, the treatment is directed to the separation of the ingredients which carry the gold. The crushing must be performed with great care, and by successive stages. All tailings must be carefully saved, since they may be further treated by a chemical process, such as the MacArthur-Forrest. Successive crushing and concentration by jigging is recommended for ores of this class. H. W. H.

THE BARTSCH PERCUSSION-BUDDLE.

Die Aufbereitung der Schlämme, insbesondere mit dem Bartsch'schen Stossrundherd. *By* Julius Schwartz. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli.*, *pages* 612-616.

The advantages of the Bartsch round percussion buddle are a conical surface combined with the equally necessary percussion-motion, a rotatory system of delivering the ore, a peculiarly curved sieve, continuous work, simplicity and efficiency. It consists of a conical iron plate or surface, resting on pulleys secured to supports below, and fixed in the centre to a bracket upon which they rotate. The percussion action is imparted by a cam which fits into a notch in the plate, and pushes it round; the notch and plate are forced back into position by two springs and driven against buffers. These impulses are rapidly repeated, and being given at the outer edge of the plate, they increase in energy from the centre to the periphery. A roller on the notch diminishes the friction of the cam, and makes the machinery work easily.

The cam-shaft drives simultaneously a worm-shaft which sets the button of the plate in rotating motion. By arranging all the driving-gear together below the plate, space is economized, and the machine is independent of all adjuncts.

The tailings are delivered to the buddle through a funnel and charging-shoot, from whence they are equally distributed over the surface of the plate. The light and worthless part of the slime is carried off at once, while the heavier minerals are deposited by the radial motion of the plate, rinsed through a curved sieve, the current of the water increasing towards the periphery of the sieve, and separated according to their specific gravities. The speed of the waste slime is only half as great when it leaves the plate as at first, and hence it is easier to separate. The intermitting thrusts are in the reverse direction to the rotating motion of the sieve, and this causes not only the deposition of the tailings but also a radial displacement of the slime, the heavier particles in it being first pushed towards the sieve. If the tailings are very rich in ore a second sieve is used. The quantity of water for the sieve is regulated by a float. The rate of delivery of the slime, the

speed of the sieve and of the stream of water, and the number and violence of the percussion movements can be varied to any extent while the apparatus is at work.

The machine only occupies 172 square feet, and can be driven by ¼ horse-power. The fall required for the delivery of the slime is 5½ feet.

In the Lohmannsfeld mining works at Altenseelbach in Westphalia, five Bartsch buddles have been erected, and experiments have proved their efficiency. The ore here treated consists principally of iron spar, with lead and sulphate of zinc, copper ore and ullmanite, the strata being composed of greywacke and quartz. The tailings are very fine mixed slime with 5·53 per cent. of lead, 8·80 per cent. of zinc, and 16 per cent. of iron, and after washing they yield—

	Lead. Per Cent.		Zinc. Per Cent.
Lead ore	68·8	...	3·15
Spathic blende	1·87	...	16·69
Residual products	1·97	...	9·30

At present from 9,900 to 11,000 pounds of tailings (dry weight) are dressed in 10 hours. More mineral and of better quality would be obtained if the ore were less difficult to dress.

In another mine in Germany with a similar apparatus and tailings of about the same quality, but more carefully sorted, the yield of pure lead was 77·36 per cent.

In a gold-producing mine at Kremnitz, Hungary, of which the author has the management, a Bartsch percussion-buddle was introduced experimentally in September, 1893, and with excellent results. Being found superior in every respect to the Frue-vanning machine formerly used in this mine, 3 more Bartsch machines were set up in the course of the year. From 10 to 12 tons of fine tailings are dressed in this buddle in 24 hours. There are 80 thrusts, and 20 revolutions of the sieve per minute, and the latter requires about 12 gallons of water per minute. With gold and silver-bearing pyrites, nearly 97 per cent. may be extracted by this machine, however rich the ore in these metals. The intermediate products are about three times as much as the clean slick. The weight of the buddle as made in Austria is about 5¼ tons, and the price about £200.

B. D.

INTRODUCTION AND DEVELOPMENT OF MAGNETIC SEPARATION OF IRON ORE.

By Axel Sahlin. *The Engineering and Mining Journal (New York)*, 1892, *vol. liii., pages* 616-617, 638-641, *and pages* 662-664, with 15 *figures.*

The author treats the subject under the following headings:—Part I., the importance and use of concentrates; Part II., preparation of the ore—(*a*) mining, (*b*) the drying process, (*c*) reduction; Part III., methods of separation, describing the following separators, viz., the Conkling, the Buchanan, Edison, Wenstrom, Ball-Norton, Hoffmann, Lovett-Finney, and the Chase.

Drawings are given illustrating the Krom crusher, the Gates, and the Sturtevant mills, also of most of the separators above-mentioned. Magnetic separators have now been used, not only to concentrate magnetite, but to separate it from more valuable ores, or from apatite, etc., which injuriously affect the iron produced at a later metallurgical stage.

The process was used successfully to separate magnetite from fine blende at Pzribram, Bohemia, and it is also used in the south of Europe for this purpose. In Australia it is used for separating auriferous bismuth ores from magnetite.

It seems probable that magnetic separation will have further applications in the future.

J. W.

CONCENTRATION OF MAGNETIC IRON-ORE AT WELDON, NEW JERSEY, U.S A.

By Axel Sahlin. *The Engineering and Mining Journal* (*New York*), 1893, *vol. lii.*, *page* 588, *with* 2 *figures.*

The Weldon mine produces about 250 tons of magnetic ore per day. The vein mined varies from 5 to 10 feet in width, and the ore averages about 40 per cent. of iron with about 0·40 per cent. of phosphorus. At bank the ore is assorted, and all lumps not purely magnetic are sent to the concentrating plant, while the clean ore, averaging about 62 per cent. of iron and amounting to about 50 per cent. of the total output, is put on cars and shipped, chiefly to the ironworks at Swedeland, Montgomery County, Pennsylvania.

The low-grade ore averages from 0·75 to 1 per cent. of phosphorus, and about 30 to 35 per cent. of iron. This ore is passed through a jaw-crusher which reduces it to about 1½ inches size, thence it goes through one pair of very efficient 22 by 15 inches Krom rolls to an 8 meshes revolving screen. Rejections from this screen are returned to the rolls.

The ore thus reduced is now conveyed to a Lovett-Finney magnetic separator wheel which consists of a shaft, on which are placed two 30 inches iron discs, 50 inches apart. The space between the discs is wound with No. 14 insulated copper wire, forming a solenoid. One end of the shaft is hollow, and through this central aperture are passed the ends of the wire which connect with the commutator attached to the shaft. From the rim of each disc extend, alternately, a number of iron bars, each bar extending almost to the edge of the opposite disc, but insulated from this as well as from the adjacent bars. The spaces between the bars are filled with non-conducting cement, giving to the finished wheel the shape of a solid cylinder, 30 inches in diameter and 50 inches long. Over this cylinder travels an endless belt of ordinary canvas, held tight by an adjustable pulley. An apron of copper is placed under the magnetic wheel, closely following the curvature of the same. Over the apron the crushed ore is carried by a liberal flow of water. An electric current of 13½ ampères and 110 volts is run through the wire of the wheel, which is revolved at the speed of 14 revolutions per minute. The discs and bars being thus magnetized, the magnetic particles of ore are attracted to the wheel, and attach themselves to the endless belt. The non-magnetic particles are in the meantime washed off and carried away by the water. When the belt leaves the top of the magnetic wheel it carries with it the collected concentrates, which are shed into a water-tank, through which the belt passes before returning to the separator. From this tank the concentrates are lifted by a flight-conveyor, and deposited directly on the railroad car ready for shipment.

To operate the concentrating plant, above described, 2 men and 1 boy are sufficient. The dynamo requires 3 horse-power, and the crushing machinery and magnetic wheel 30 horse-power, a total power of 33 horse-power.

The concentrates had, during the past six months, averaged about 67 per cent. of iron, while the tailings had not run above 8 per cent. J. W.

MAGNETIC CONCENTRATION OF IRON-ORE AT THE CROTON MAGNETIC IRON MINES, BREWSTER, NEW YORK, U.S.A.

By W. H. Hoffman. *Transactions of the American Institute of Mining Engineers*, 1891, *vol. xx.*, *pages* 602-609.

In 1888, the author was engaged by the lessee of the above mines to adapt an old water-jigging mill to the magnetic process. The ore to be treated consists of compact, moderately fine-grained magnetite in a gangue composed mainly of quartz

and hornblende, besides felspar, apatite, and mica, and more or less pyrites and pyrrhotite. The grain of the ore permits a fair disintegration of its constituents by crushing it to pass a 12 meshes screen (a finer mineralization would increase the cost of concentration).

The ore has been examined by Messrs. E. McMillan and F. W. Gordon and Prof. N. S. Shaler, who state that the average amount of metallic iron in the ore beds ranges from 37 to 42 per cent., sulphur averages from 1·7 to 2·2 per cent., and phosphorus from 0·07 to 0·43 per cent. Since May, 1891, they have been roasting and concentrating this material to 68 per cent. in metallic iron, 0·44 per cent. in sulphur, and 0·036 per cent. in phosphorus. Previous to this, the concentration ran about 66 per cent. of iron.

The Croton mines have produced and sold at a fair profit from 50 to 220 tons of concentrates per day during the years 1890-91, the mill having only been at work 20 months. Commercial success in concentrating any ore includes economical mining, preparation, and separation; but in the Croton ore the presence of sulphur calls for very economical roasting, as well as economy in all the other processes.

The cheap roasting of the ore of the Croton mine, which contains about 2 per cent. of sulphur, was really one of the first problems encountered in reclaiming that property, and was really as important a factor as the concentration.

The best size of the ore for economical roasting was found to be such as would pass through a $2\frac{3}{4}$ inches ring, and give the most rapid work for the quantity of fuel consumed. Crude Lima oil is used for roasting, 3·6 gallons being used per ton of raw ore. The average temperature of the roasting is 1,250 degs. Fahr. Davis-Colbey roasters, remodelled to burn oil, are used, and have done excellent service. Hoffman roasters are also in use.

The ore is conveyed automatically from the roasters to the Sturtevant mills, where it is ground to 12 meshes size, all coarser material from the screens being returned to these mills by elevators. Barring the numerous experiments with various types of magnetic separators, the experiments in crushing have been most elaborate. Nearly all the best known methods of grinding ores have been tried at the Croton mines during the past 3 years. The Sturtevant mill has proved superior to any other machine for grinding iron ores. The screen-block openings in the Sturtevant mills are $\frac{1}{4}$ inch wide, and the coarsest material passing through them is less than $\frac{1}{3}$ inch thick, while the finest material would be rejected by a 60 meshes screen. After cooling to 350 degs. Fahr., the ore is quite friable as it enters the Sturtevant mills, and there is no difficulty in grinding 22 tons per hour with the 20 inches mill, and 16 tons in the same time with the 15 inches mill. One set of Sturtevant mill-bushings will grind from 4,000 to 6,000 tons of ore (according to the depth of the chill in the bushing), the cost of each set being 16 dollars. The screen-blocks for this amount of ore cost 9 dollars. This is less than one-half the cost of renewal on any other machine formerly used at this mill. At 22 tons per hour the 20 inches mill requires 94 horse-power to drive it, and the 15 inches mill requires 70 horse-power. The ground ore from the Sturtevant mills is elevated to screens, covered with slotted steel plates.

The screens deliver their finished product to two bins, placed on the floor above the separating department, each having a capacity of 80 tons. Eight chutes deliver the ore to the separators, nine in number. The separators were designed and constructed by Messrs. W. D. Hoffman and T. Blass at the Croton mines. On eight of the machines, the ore is passed before the magnets twice to bring the loss in tailings to 8 per cent. Mr. W. D. Hoffman has lately designed two new separators, one of which is giving, with one pass, concentrates of 68 to 70 per cent., with a loss of 6½ per cent. of iron in the tailings. The cost of separation is about 3½d. (7 cents.

per gross ton (2,240 pounds) of concentrates, and this includes all repairs to separators. Repairs and supplies throughout the milling plant amount to 0·9d. (1·8 cents) per ton of raw ore ground.

During the previous winter and spring a continuous run of five months was made of 20 hours each day, and the average cost of a gross ton of concentrates for the whole term was 8s. 9d. (2·10 dollars). Improvements had reduced this amount to the figure of 8s. (1·95 dollars) per ton. J. W.

THE ORE-DEPOSITS OF NAGYBÁNYA (HUNGARY).

Die Erzlagerstätten von Nagybánya in Ungarn. *By* Geyza Szellemy. *Zeitschrift für praktische Geologie*, 1894, *pages* 265-271.

Rising suddenly out of the great Hungarian plain, the Wihorlet-Gutin chain, the "Erstwhile Burning Mountains," ranges from south-east to north-west at heights of 5,000 feet, and walls off the county of Marmarosch from those of Szatmar and Ugocsa, as well as from Transylvania and Bukovina. Here in Tertiary times took place the most violent and the most extensive volcanic outbursts that have ever been traced in the European area; and with the trachytic and tufaceous rocks, the long-cooled products of those outbursts, are associated many important ore-deposits. Messrs. Fichtel, Beudant, F. von Richthofen, Szabó, and Alex. Gesell have successively classified and described the rocks. These are chiefly amphibole-, pyroxene-, and biotite-trachytes, rhyolites, basalts, andesites, and propylites, the last-named being termed "greenstones" by the miners.

Along the whole range, wherever the andesite broke through the Tertiary and crystalline rocks, it dislocated and rent them, and in some localities the ores have concentrated in the fissures of the rocks thus shattered. It is observable in these cases that all indications of metalliferous ores disappear as one examines the rocks farther away from the andesitic eruptions. Later, the andesite was in turn burst through by the trachytes and rhyolites, was fissured and metamorphosed into "greenstone," and the cracks were filled by sublimation with ores, forming the numerous lodes which we now see.

The history of the very ancient mining industry in the Nagybánya district is briefly sketched, and the author then proceeds to describe:—

(1) *The Kreuzberg Mining-field.*—This covers an area of about 370 acres. The lodes have no salband; they consist of impure quartz impregnated with native gold in an extremely fine state of division, and with auriferous and cupriferous pyrites. Moreover there are "nests" and clefts filled with silver ores. The average metallic content per ton of ore is 25 to 30 grammes of gold, and 100 grammes of silver (about 0·81 to 0·97 ounces troy of gold and 3·3 ounces troy of silver per ton). A detailed table is given of the gold and silver production at Kreuzberg from 1863 to 1892, both years inclusive. The present average annual production of ore is 8,000 tons. A crushing-mill with 75 stamp-heads and 11 sweep-tables is at work.

(2) *The Veresviz* (*Red Water*) *Deposits.*—The stream which runs through this valley is deeply tinged with iron oxide. The lodes all strike nearly parallel north and south through the "greenstone" mountains of the Veresviz and four tributary valleys. The gangue here is calcite as well as quartz; in the latter, the native gold occurs in strings and flakes, often in well-formed octahedra and in model twins. In the pyrites, the gold appears to be chemically combined, as it cannot be obtained by amalgamation. Besides occurring in brittle ore, ruby ore, and as a

sulphide, silver is here found native in various forms. Out of 53 claims, 37 belong to the Hungarian Treasury: mining is at present conducted only by means of adits, and no deep workings have so far been attempted. The ten principal lodes are described in detail, and besides these a great many others are being worked. The annual production ranges from 4,000 to 9,000 tons. Connected with the mines by a 3½ miles railway are three crushing-mills, with 78 stamp-heads and 16 sweep-tables. The mills are now being fitted up with steam machinery and electric transmission of power, so as to make them independent of fluctuations in the water-supply. O. S. E.

THE ORE DISTRICT OF CINQUE VALLI.

Geologische Verhältnisse des Erzreviers von Cinque valli und Umgebung. By Josef Haberfelner. *Zeitschrift für praktische Geologie*, 1894, *pages* 134-142.

A minute description of the rocks in which the principal veins of ore occur in the Cinque Valli district is given. It is considered to be a sort of contact-stone, that is to say a rock produced by a melting of the slaty rocks by the granite and a mingling of the two.

The mineral matter was originally disseminated through the rocks. Afterwards it was dissolved out by water, and redeposited in fissures. The metals represented are lead, copper, arsenic, etc.

The whole area from Roncegno to Pergine, through Fersina to the lake of Palu on the one hand, and from Pergine to the Pinè Valley on the other, may be considered a great ore-district. It is a favourable district for mining in the future as it has been in the past. At least 30 veins are known. G. W. B.

THE ORE-DEPOSITS OF FINLAND, RUSSIA.

Om Finlands malmförekomster. By Axel Tigerstedt. *Vetenskapliga Meddelanden af Geografiska Föreningen i Finland, Helsingfors*, 1893, *vol. i., pages* 79-93, *with figures in the text and plates V.-VIII.*

The deposits of greatest industrial importance are the bog-iron ores, the deposition of which is still going on during our own day. The yearly production of cast-iron from these ores has throughout the century averaged a value of £50,000. The magnetic iron ores occur in lenticular nests in the most ancient rocks of the country: they are generally of poor quality, and not very abundant. Only two mines in Finland are at present working these ores. North of Lake Ladoga are fine examples of iron ore of eruptive origin, *i.e*, ore which has welled from the earth in a molten condition: the same origin is attributed to the magnetic iron pyrites with cobalt and nickel, which occurs south of Lake Saima. The author explains these as the result of "metallic liquation from the surrounding basic rocks."

He regards the copper ores of Orijärvi and Pitkäranta as having been vaporized or sublimated from the interior of the earth. At both localities the ore is visibly stratified. The ore at Orijarvi has been largely exhausted; but the workings at Pitkäranta are in active progress, the present production (annual) averaging 200 tons of metallic copper, about 20 tons of zinc, and rather less than half a ton of silver. Much zinc-blende is found in both mines.

In the north-eastern part of the duchy are innumerable cupriferous quartz-veins, but although they form a network over a large area, they seem too poor to be of much industrial value. In these the ore probably came in from the sides, in aqueous solution.

There are extensive gold-washings in Finnish Lapland, along the bottoms of the river-valleys. From 1870 to 1889 inclusive, the total gold production amounted to 11,552 ounces troy, the average proportion of the precious metal being 0·704 ounce for every 35 cubic feet of "slicks" washed.

On the whole, Finland cannot be regarded as a country rich in metalliferous ores, although most of the chief varieties are recorded as occurring there.

The paper is accompanied by tables giving the statistics of production of the iron-ores and copper-ores for a long series of years. O. S. E.

THE NORTHERN PORTION OF THE SIERRA DE USPALLATA, ARGENTINE REPUBLIC.

Estudios mineros en la Provincia de Mendoza: la Parte Septentrional de la Sierra de Uspallata. By G. Avé-Lallemant. *Boletin de la Academia Nacional de Ciencias en Cordoba (R.A.), vol. xii., pages* 131-176, *and* 3 *plates (maps and sections).*

The Sierra de Uspallata runs east of the Rio de los Patos, in the province of Mendoza, parallel to the Cordillera del Tigre of the Andes. The topography, orography, and hydrography of the region are described at some length, and the author then proceeds to deal with its geology. The rock-formations which constitute the sierra are the Huronian, the Lower Silurian, the Upper Trias and Rhætic, the Tertiary sandstones, and the alluvia, interrupted by or alternating with six several eruptive formations.

The Huronian includes much-cleaved phyllites of a silky lusture, chlorite-schists, a great spread of calcareous rocks (limestones, dolomites, and calc-schists), with dykes of diabase and great masses of serpentine. In the Quebrada de la Cortadera the fine colouration and veining of the serpentine are such as would make it eminently suitable for use in the arts. The rock is easily worked, and a market could be found in the country itself.

The Silurian, lying conformably upon the Huronian, consists of greenish grauwackes and slates, much folded, contorted, and dislocated, and dipping steeply to various points of the compass. The author found no fossils in these rocks. Upon them lie the variegated pebble-beds and sandstones (some plant-bearing, others gypsiferous), and the variegated marls (often bituminous and carbonaceous) of Upper Triassic or Rhætic age. Through these protrude dykes and sheets of olivine-diabase or palæodolerite. In the metalliferous mining district of Paramillo, coal occurs in appreciable quantity in these Rhætic strata, but not sufficiently to make it workable. In the Silurian grauwackes, but chiefly in the Southern Sierra, occur veins with auriferous galena of low grade.

Red sandstones and conglomerates, the latter containing huge boulders of trachyte, interbedded with flows of reddish sanidine-trachyte, unconformably overlap the Rhætic and Huronian. These strata are, presumably, of Kainozoic age.

A dark-red to purple orthoclase-porphyry attains a great development in the south of the area, and is associated with tuffs and breccias. The Tertiary eruptives comprise, besides the trachyte, tuffs mainly yellowish-grey in colour and hornblende-andesites. The latter are sometimes found injected into the dolerites (mentioned above), and they have metamorphosed the Rhætic beds even more completely than the dolerites have done. The masses of andesitic tuff intruded amongst the stratified rocks form the "country" of the metalliferous veins.

Auriferous quartz is known in two districts of the Northern Sierra, and has been worked for many generations, but the only mine open at the time of the

author's journey was that of Los Boques. There the chief veins cut through slate-coloured chert or lydianite, while at Agua de la Mina, in the Sierra Aspera, they cut through the andesite. The auriferous veins may therefore be classified in two of the categories of Prof. Groddeck, *i.e.*, the Australian-Californian type, cutting through metamorphosed sedimentaries, and the Nagyag type, running through igneous rock; yet both are here associated with the andesite formation.

Some of the abandoned gold-workings were to be reopened, as a company was engaged in setting up the necessary machinery.

Two deposits of copper-ore are known in the Northern Sierra. They both belong to the same type: thus at the Cañada Larga a mass of andesitic tuff is irregularly impregnated with copper silicate and malachite, but farther down the ore would appear to be copper pyrites. Native gold occurs of poor quality.

Silver-ores have been worked in the district since 1638, and the richest vein was the Vallejos; the workings in this have been long abandoned, but a company has now put down a shaft to cut the vein at a considerable depth. The other principal veins are the Alcaparrosa, Vetillas, and Trinidad. The silver-ores occur mostly in association with the dolerites, but some of the veins cut through the Rhætic plant-bearing sandstones and conglomerates. The system of veins spreads in the shape of a fan, the extreme radii of which are the Santa Rita Alta and the Alcaparrosa. The "fan" opens at an angle of 91 degs. 30 mins. to the west, and the maximum length of radius is 3½ miles. The veins are compound or multiple, consisting of several metalliferous leaders running, not always parallel to one another, through the encasing rock. Thus the total thickness of the Vallejos vein, even at a depth of 165 feet, attains 11½ feet; the Vetillas is 6½ to 10 feet thick; and the Alcaparrosa, 6½ feet. The smaller and very much narrower (7 to 19 inches) veins often do not exceed 300 feet in length, but they are none the less of industrial importance, because the ore in them is massive and abundant; these only cut through the dolerites. The vein-stuff is the same everywhere: massicot, spathose iron ore, hornstone, quartz, calcite, and seldom barytes. The ore itself is usually cerargyrite (silver chloride) and embolite (chlorobromide), while deeper down occur galena, blende, chalcopyrite, etc. Native silver is not of common occurrence. At the Carranza mine, a low-grade galena (0·55 per cent.) is worked, but the ore is abundant. The great enemy of the miner has been the water, which, accumulating in the bands of clay and tuff in between the dolerites, has broken into some mines over and over again; but new plant has been put down to overcome this difficulty.

The mining industry in this region is practically in the hands of the *Sociedad Minera del Paramillo de Uspallata*. They have now sunk four big shafts, and have erected works for treating the ores. O. S. E.

THE MINERALS OF BRAZIL.

By J. Ross. *The Engineering and Mining Journal* (*New York*), 1895, *vol. lix., page* 125

Brazil has a great diversity of soil, minerals, and products; but, as other conditions are wanting, many of the minerals cannot be worked profitably. For example, such minerals as lead, copper, and iron ores, which occur, cannot be smelted for want of coal. Silver does not occur to a sufficient extent to pay for working.

A mine of quicksilver has recently been discovered in western Bahia, which may prove of considerable importance. Agates abound in the State of Rio Grande do Sul; some are exported to Europe, *viâ* Montevideo, but there seems little demand. A pile of about 50 tons of agates has lain at the port of Salto Urugua for 10 years.

Diamond mining in Brazil was formerly carried on to a large extent. Now, it has greatly diminished, labour being dearer in Brazil and the price of diamonds having fallen through larger stones being found in South Africa. The Brazilian diamonds are hard, but comprise fewer large stones than the South African. Of the six most famous diamonds found in the world, Brazil has furnished two, the "Southern Star" of 254 carats and the "Diamond of the Crown of Portugal" of 120 carats.

The country is rich in gold-mines, which might be worked profitably if foreigners could secure legitimate protection in their mining rights.

The Brazilian gold-mines have all been, and still are, worked in an antiquated fashion, a profitable percentage of gold being lost with the tailings. Formerly, in the days of the slave trade, labour being much cheaper, gold-mining was carried on much more profitably. J. W.

THE ORE-DEPOSITS OF PUÑITAQUI (CHILE).

Die Erzgänge zu Puñitaqui in Chile, mit besonderer Berücksichtigung der Zinnober-führenden Lagerstätten. *By* A. Götting. *Zeitschrift für praktische Geologie*, 1894, *pages* 224-230, *with sketch-plan in the text.*

The quicksilver deposits of this district of the coastal Cordillera are known to have been first worked in 1785 by the Spaniards, and, with very defective appliances, the ore extracted and treated on the spot yielded 4 per cent. of metallic mercury. After a break of 40 years, work was begun once more at the end of the 'fifties and then again dropped.

In the native tongue "Puñitaqui" is said to mean "gold land." It is certain that both natives and Spaniards at one time worked the auriferous and cupriferous lodes, but the industry perished in the revolutionary wars, and the existence of gold in the area under review was only re-discovered in 1880.

The mountain *massif* consists of syenites and diorites, interrupted by a broad belt of intrusive diabases (uralite-porphyrite and diabase proper). The latter shoot through the rocks in dykes, or spread out above them in sheets, and alter them at the contact into hornblende-granitite. Numerous instances of passage from one variety of diabase into the other are seen, and various stages of decomposition of the rocks are particularly observable in the neighbourhood of the metalliferous lodes. In basin-shaped depressions at the summit of the ridges are deposits containing a great variety of rocks, evidently derived from the main Cordillera, and probably smoothed by glacial action. It is in the diabase zone that the quicksilver ores and the auriferous and cupriferous lodes occur. Few lodes, and these of small importance, continue into the syenites and diorites; some are observed at the contact between diabase and granitite. Practically, the only gold and copper ores now worked thus occur at the contact in the southern portion of the area, at the Manto mine. There the gangue is a ferruginous auriferous quartz, with cavities containing gold-impregnated brown iron ore. The lodes are not thick, they join together frequently, are very variable in strike, and "pitch" steeply. Specular iron ore and tinstone have been found, but have not hitherto been worked, in the district.

The fifty or so known metalliferous lodes are grouped by the author in two categories. The first is the most important. The veins strike generally north and south, spread out northwards, and converge southwards to the diabase-granitite contact. The second, of less importance, strikes generally south-south-west and north-north-east, faulting the north-and-south veins. The average

thickness varies from 3¾ to 6½ feet, but where two systems of veins join, it reaches 10 to 18 feet. The state of decomposition of the "country rock" is remarkable, and appears to be entirely unaffected by such factors as relative depth or percolation of pit waters; and the more decomposed the "country rock" is, the richer the lodes appear to become. Quartz is the typical vein-stuff and the usual associate of the cinnabar, together with iron and copper pyrites, specular iron ore, and mercurial fahlore. Nearer the surface, malachite and azurite also occur. The author then describes in some detail the mineralogical aspect of the deposits.

The average percentage of copper in the good lodes is 12 to 14 per cent.; with only 8 to 10 per cent., the lode is considered unworkable. Workings are closed or re-opened according to the fluctuations in the market price of copper. The gold content averages 20 to 30 grammes per ton (0·65 to 0·97 ounces troy per ton) of vein-stuff. The deeper down the workings are carried, the more the gold content diminishes, while the proportion of iron pyrites increases, and the same complaint is heard as regards the percentage of copper in the Manto and Cerro de Tamaya mines. With regard to the quicksilver deposits, the French company to whom the author reported decided not to re-open them, as, despite the encouraging conclusions drawn from what he saw of the old workings and the old waste-heaps, he admitted that deep workings would afford little prospect of permanent success. Nevertheless he thinks that the gold-bearing lodes would repay working, as the mass of material which can be worked up is large, and the local conditions are favourable. In this case, as in that of the copper ores and in that of the so far neglected tinstone, the chief requisites are adequate capital and modern methods of working. O. S. E.

MINING INDUSTRY IN RUSSIA.

Aperçu général sur l'Industrie minérale de la Russie. *By* A. de Keppen. *Annales des Mines*, 1894, *series* 9, *vol v.*, *pages* 180-273 *and* 279-368, *plates VII.-VIII.*

The first few pages are devoted to a brief historical summary of mining administration and legislation in Russia from the days of Peter the Great downwards. Turning then to the actual condition of things, the author premises that in Russia "mining industry" not only implies quarrying of rock, extraction of ore, etc., but also metallurgy and chemical treatment of all mineral products, the one exception being the manufacture of (refined) petroleum which comes within the sphere of the Ministry of Finance. Mining administration in the Empire is directed by the Department of Mines of the Ministry of Domains; but the Minister for War looks after the mining affairs of the country of the Don Cossacks, while the Ministry of the Imperial Court superintends those of the Altai and Nerchinsk districts of Siberia. Finland is administered separately and possesses a Mining Code of its own, enacted in 1883. For the Empire as a whole, there is no complete and systematic Mining Code, but in volume vii. of the General Code of Laws are set forth the various enactments on mining as modified up to 1893. As to education, besides the great school of the Institute of Mines at St. Petersburg, where the highest grade of instructi n is attainable, there are the secondary mining colleges of Ekaterinburg (Ural), Barnaul (Altai), and Dombrowa (Poland), and in the Donetz coal-field the master-miners school at Lisichansk and the Poliakoff school. The number of these is now being increased by the new primary and secondary technical schools recently started under the auspices of the Ministry of Public Education. Moreover, a new school of mines is to be established at Irkutsk, for the especial purpose of training subordinate officials for working gold-deposits in Siberia.

The great and steady development of mining industry in the empire since 1825 is shown in a series of statistical tables. In 1891, the total value of the principal minerals extracted and treated metallurgically or otherwise reached the sum of £12,626,500. The number of workpeople employed was 440,517, and in comparison with the mining industry of other countries, that of Russia would seem greatly overmanned. But the reason is not far to seek: the widespread use of charcoal fuel in Russian works necessitates a vast amount of preliminary handling, and consequently an increased number of workpeople as compared with countries where coal is the chief fuel.

Dealing *seriatim* with the mineral resources of the Empire and the methods of working, etc., the author first devotes attention to:—

1. *Gold.*—In the Orenburg government, the Southern Urals are characterized by small and irregular placers worked by small syndicates. The same remark applies to those of the province of Perm, the only large placers in European Russia being those of Bogoslovsk, in the extreme Northern Urals. The placers of Western Siberia (Altai, Tomsk, Achinsk, and Minusinsk) are, generally speaking, poor—some workings barely suffice to keep a dozen or a score of men busy, no horses being required in such cases for the crushing apparatus. So, too, the Yenisei gold-deposits have seen their best days, and the remnants of their former wealth are just adequate for the maintenance of a small local mining industry. On the other hand, the placers of Nerchinsk, the Amur basin, Yakutsk, and the Lena basin are extensive, continuous, and rich, some of them yielding as much as 28,000 to 56,000 ounces of the precious metal annually. Comparatively speaking, very little gold is got in the Russian empire from auriferous quartz-veins. What mining there is of that description has developed much more rapidly in the Urals than in Siberia. In 1891, Russian gold-production amounted to 1,380,640 ounces, of which only 84,160 ounces represent metal obtained direct from auriferous quartz-veins. Many complex circumstances besides seasonal variations affect the annual production; among them, changes in taxation, fluctuations in the rate of exchange of the paper rouble, and alterations in mining legislation, play no inconsiderable part. The gold obtained from all mines or placers in the empire has to be sent to one of the three State smelting-works, established at Ekaterinburg, Tomsk, and Irkutsk, the cost of cartage thither being borne by the producer. The latter also pays for the additional freight to the Imperial mint at St. Petersburg and for the cost of minting the bars into coin. These expenses are, of course, supplementary to the royalties and taxes (payable to Government) which are practically proportional to the richness of the claim worked. The State banks advance money to the mining syndicates on the security of the crude metal.

The author gives several statistical tables regarding gold-mining in the Russian Empire, one of which shows the actual amounts produced and quinquennial averages from 1816 to 1891 inclusive. He also gives a summary of the legislation, and one notes that, although foreigners are equally entitled with Russian subjects to work auriferous deposits, the right is denied to the unfortunate Hebrew.

2. *Platinum.*—This metal is found in the Urals, near the boundary of the province of Perm, in placers which are often auriferous and are extremely variable in richness. The platinum occurs usually in small grains, and osmium and iridium are often found in conjunction with it. These placers of the Urals are the only known sedimentary platiniferous deposits, and recently platinum has been found in a mother rock (or true matrix) of chrome iron and serpentine. The precious metal is sent in the crude state to St. Petersburg, whence most of it is exported (without being refined) to foreign countries. In the table of exports during the years 1884-

1891, Great Britain appears as much the largest consumer until 1891, when the export to this country is marked as *nil*, and Germany takes the whole. There is in Russia a tax of 3 per cent. on platinum mined on private lands and 4½ per cent. on claims granted by Government. The enormous fluctuation in prices affects the amount produced, high prices constituting, of course, an incentive to work the very poorest placers. Platinum was used in Russia for coinage into 3, 6, and 12-rouble pieces between 1828 and 1845; but that use of it was abandoned in the last-named year, and the production immediately dropped to a very low figure until 1859, since which year it has steadily increased to the present annual average of 150,000 ounces; the extraction whereof employs 6,120 workpeople.

3. *Silver.*—All the silver got in Russia is extracted from argentiferous galena; but it should be borne in mind that all native gold of Russian origin is more or less argentiferous. Since 1831, the total silver production in the Empire has been slowly but continuously decreasing, although in particular districts, such as the Altai and Nerchinsk, it has begun to increase again of late years. The taxes bear the same proportion to value as in the case of platinum. The silver production in 1891 was 485,000 ounces (13,723 kilogrammes).

4. *Copper.*—The production of this metal attained its maximum in Russia between the years 1845 and 1852. At that time France appears to have been Russia's largest customer. The falling off since 1852 was attributed, among other causes, to the liberation of the serfs and to heavy taxation, indirectly favouring imports of foreign copper. In 1884, however, the Imperial Government imposed a protective tariff, and since then the copper industry has gradually revived, the total production increasing from 3,592 metric tons (3,535 British) of metal in 1882 to 5,455 metric tons (5,367 British) in 1891, an increase of 52 per cent., with 106 mines at work.

The two most important centres of the industry are the Bogoslovsk works in the Urals, and the Kedabek works in the Caucasus. At the first-named there is the necessary plant for enriching the ore in the wet way, the copper is extracted from its solutions by electricity, and the matt is treated by the Bessemer process. At the Kedabek works, petroleum-residues are used for heating the furnaces. On the western slopes of the Urals the ores occur in masses and nests in the Permian formation, while on the eastern they occur as veins in other formations. They are all of poor quality, but those of the Caucasus are rich, and those of the Kirghiz steppes (where work is at a standstill for want of fuel) are still richer. Russia, in 1891, imported nearly as much copper as she produced, about half coming through England and most of the remainder through Germany.

5. *Lead.*—All the lead got in Russia is extracted from argentiferous galena, which is worked in the Caucasus, Siberia, and the Kirghiz steppes. The total production of the metal in 1891 was only 556 metric tons (547 British). Russia has therefore to depend upon foreign countries for her lead supply, and the imports in 1891 averaged 20,000 tons, rather more than 55 per cent. coming from England. Plumbiferous ores have been recently discovered in the Governments of Arkhangelsk and Ekaterinoslav, associated in the latter case with zinc ores.

6. *Zinc.*—At present the production of this metal is confined to the southern part of Poland, although zinc ores are well known in other districts of the Empire. The Polish ores are calamine, lying in the Muschelkalk dolomites near the town of Olkusz. Two sheet-zinc works and a zinc-white factory have been established in Poland. The total production, however (some 3,200 tons of metal, 800 tons of white annually), is insufficient for the needs of the Empire, and 5,145 metric tons (5,061 British) of zinc was imported in 1891, most of which came from England.

7. *Tin* is worked only at Pitkäranta, in Finland, and the production is insignificant—9 or 10 tons annually. The imports average 2,000 tons every year, 70 per cent. being British.

8. *Mercury.*—In 1879, a rich deposit of cinnabar was rediscovered in the Government of Ekaterinoslav, near Nikitovka, on the Azov railway. It occurs as an infilling of fissures in sandstone of Carboniferous age. Mining was started in 1885, and the plant and machinery are of more modern type, and produce better results in proportion than the older works of Idria and Almaden. In 1891, with 746 workpeople, the production was 324 metric tons (318 British) of metallic mercury, about seven-eighths of which quantity was exported to Germany.

9. *Manganese.*—The most important workings are those of Charapansk, in the Government of Kutais, Southern Caucasus. They were started by large capitalists in 1879, but are now in the hands of a number of small owners, who are in very few cases expert in mining methods. The deposits cover an area of 31,616 acres, and occur as a band from 3¼ to 6½ feet thick, comprising six to eleven seams of pure ore, each of which is ¾ inch to 5 inches in thickness; they contain 56 per cent. of metallic manganese. A branch railway takes the ores direct on to the Transcaucasian main line.

Near Nikopol, in the Government of Ekaterinoslav, a manganiferous band, maximum thickness 20 inches, runs through Eocene strata. Two mines were opened there in 1886, and the assays show that the ore contains 57 per cent. of metallic manganese.

The total production of manganese ores in Russia in 1891 was 113,081 metric tons (111,263 British), whereof 100,000 came from the Caucasus. A very small quantity of ore is treated in Russia, most of the raw stuff being exported to the United Kingdom, Holland, and Germany.

10. *Cobalt and Nickel.*—There is a cobalt-works at Dashkessan, in the Government of Elisabetpol (Caucasus); it was started in 1867. Nickel, too, occurs in the Caucasus, in Daghestan, and at several localities in the Urals; but the most important nickeliferous deposits are those of Revdinsk (Ural), discovered in 1850. At that locality is the only natural nickel-oxide in Europe that is almost entirely free from sulphur and arsenic. The average metallic content of the ore is 2 per cent. Reliable statistics have not been obtainable for the period previous to 1874; since that year the total production has been 59 metric tons.

11. *Iron.*—The richest deposits of magnetite in the Urals are those of Blagodat (52 to 58 per cent. of metallic iron), Vissokaia (63 to 69 per cent. of metallic iron, no flux necessary), and Magnitnaia (66 per cent. of metallic iron). Deposits of less importance occur on the eastern flank of the chain, while in the north of the Urals a beginning has been made with working a specular iron ore, for treating which the Kutinsk works were built in 1890. The largest deposits of good brown hæmatite, yielding 60 per cent. of metal, and especially suitable for the Bessemer process, occur in the Central and Southern Urals. The red hæmatites of the western slopes yield 64 per cent. of metal, and chrome-iron ores, containing 35 to 38 per cent. of chromic oxide and 40 to 50 per cent. of iron, are worked at several localities. Ores of inferior quality, and generally containing phosphorus, are worked in Central Russia, and in the Government of Olonetz and the Grand Duchy of Finland. In Southern and Western Poland clay-ironstones, with 27 to 35 per cent. of iron, and brown hæmatites, with 35 to 45 per cent., are very extensively worked. These ores also are mostly tainted with phosphorus. In Southern Russia (Donetz-Kherson-Ekaterinoslav) are enormous deposits of very rich and pure magnetites, red hæmatites, and specular iron ore (60 to 68 per cent. of metallic iron); workings in them have developed astonishingly within the last few years.

In 1891, there were in the Empire 682 mines at work and 202 bog-iron ore workings ("lakes"), producing during the year a total of 2,958,378 metric tons (2,926,904 British). The fuel used in the manufacture of cast-iron is mainly wood charcoal, but in Central Russia and Finland firewood also is used, and peat in Poland. In the whole of Russia in 1891, only 16 blast-furnaces fired with mineral coal and coke were in blast (5 in Poland and 11 in Southern Russia), but the statistics show that these fuel proportions are in rapid process of reversal. The number of old-fashioned cold blast-furnaces fired with wood charcoal is yearly diminishing (50 per cent. of cold blast in 1882 and 31 per cent. in 1891), while modern plant and modern methods are asserting their mastery.

The iron production of furnaces fired with mineral coal, which in 1882 was only 7·7 per cent. of the Russian total, in 1891 was 32 per cent. Tables are given showing the progress of the Russian iron and steel industry from 1822 down to the present day, and they demonstrate, among other facts, that the production of cast-iron has more than doubled within the last ten years, while that of bar and sheet iron and steel has nearly doubled. All this increase must be credited to Southern Russia.

A succinct account is given of the various attempts to create and foster the steel-rail industry in the Empire. These were only attended with success after the Imperial Government's inauguration in 1876 of a system of bounties on Russian rails and duties on foreign rails

The Volga and its affluents, which, for the ironworks in the Urals, constitute the chief transport-routes, are closed by ice for four or five months of the year; while the ironworks of Poland, Central and Southern Russia, being in more direct communication with the great network of railways, are never thus cut off from their markets. Much of the iron made in the Urals is sold at the great fair of Nijni Novgorod. It is curious to note that Great Britain at the end of the eighteenth century was a relatively large importer of Russian iron. The imports into Russia of foreign iron and steel have been in process of diminution since 1878, partly because of the enormously increased customs duties, and partly because of the development by the Russians of their own iron and steel manufactures.

12. *Coal.*—The real rise of the coal-mining industry in Russia dates from 1855; up till that year Poland and Southern Russia produced between them roughly 150,000 tons of coal annually. Since then, not to speak of the Donetz coal-field, collieries have been opened up in Central Russia, in the Urals, in the Caucasus, and in far Eastern Siberia (mainland and Saghalien). On the railways alone the annual consumption of coal has increased from 498,358 metric tons (490,348 British tons) in 1875 to 1,388,086 metric tons (1,365,777 British tons) in 1891. On the other hand, the quantity of foreign coal so consumed has diminished from 286,868 metric tons (282,257 British tons) in 1880 to 102,521 metric tons (100,873 British tons) in 1891. Exact statistics as to the coal consumption in other branches of industry are not forthcoming. The total imports of coal and coke had not decreased much in 1891 in comparison with 1876, the annual average being steadily maintained at about 1,700,000 tons. The total production of coal in the Russian Empire in 1891 was 6,233,020 metric tons (6,132,846 British tons) from 323 collieries (950 shafts), employing 462 steam-engines and 40,225 workpeople (of whom 30,722 were at work below ground). The averages of production per pit and the average number of engines per colliery are much higher in Poland than in the Donetz and other coal-fields (the relation is about 10 : 1 for coal, 9 : 1 for engines). This enormous disproportion is partly explained by the fact that there is in Poland a settled population of experienced miners, and that most of the coal there is got from a

single seam varying between 25 and 50 feet in thickness, while in the Donetz basin the seams are rarely more than 6 or 7 feet thick.

The Donetz basin may be divided into three zones—the central and most extensive, where Carboniferous rocks come to day, and the eastern and western zones covered by more recent deposits, with here and there island-like inliers of Carboniferous. The total coal-bearing area of the Donetz is estimated at 4,942,000 acres, while that of the whole of Southern Russia is about double this figure. The country is gently undulating, cut here and there by deep ravines, and lies at an average height of about 500 feet above sea-level. As above-mentioned, the coal-seams are very rarely more than 6 or 7 feet thick, and the seams which have a thickness not exceeding 3 feet are, as a rule, quite pure coal, while the thicker seams are more or less intermixed with shale and sandstone. Roof and floor are mostly shales and sandstones. Almost every variety of coal occurs in this basin—gas coal, slightly bituminous and highly bituminous coals, semi-anthracites and anthracites. Statistics are given showing the enormous development of coal-mining in the Donetz since the days of the Crimean war. In 1891, there were 152 mines working anthracite and 125 working other coals, the former producing roughly 650,000 tons per annum, and the latter roughly 2,350,000 tons. The Donetz coal is not so much consumed within the district itself as exported to other parts of the Empire, the city of Odessa, which formerly depended on British coal alone, being a large customer.

The Central or Moscow coal-field covers an area of about 5,928,000 acres, and from it stretches a long strip of Carboniferous rocks through the governments of Olonetz and Arkhangelsk to the shores of the White Sea. The strata are predominantly limestones, the Coal-measures being intercalated between the lower limestones and the Devonian. There are only 12 outcrops now worked in the basin out of 200 known. The coal is difficult to work, often of bad quality, contains much ash, yields no coke, and cannot with advantage be carried to great distances or stored for any length of time.

The Kiev-Elisabetgrad basin is notable for its thick beds of Tertiary lignite, which extend into the province of Kherson, the total area of possible lignite-bearing beds being estimated at 1,235,000 acres.

The Polish coal-field, situated in the south-western part of the old kingdom of Poland, is in reality a prolongation of the Silesian coal-basin. The estimated area of coal-bearing strata in this field is 1,432,600 acres, but only about one-seventh of that area is in Russian territory, the remainder lying across the Prussian and Austrian frontiers. The surface of the country is somewhat hilly, with a general dip to the south-west, in which direction the older deposits are seen to come on from under the newer. The Carboniferous outcrops are surrounded by Triassic and Jurassic rocks, and occur at an average height of 900 feet above sea-level. Three great groups of seams are recognized, the chief of which, or Reden group, is the same as the Sattelflötz group of Prussian Silesia. The Reden seam itself varies in thickness from 25 up to 65 feet. As one goes westward, shales come in which split this great seam into three or four, the thinnest of them averaging $6\frac{1}{2}$ feet; and this westerly variation is accompanied by a change in the character of the coal. In the Polish area the Reden seam yields no coal which is good either for coke or for gas manufacture. Twelve seams occur above it and nine below, the total thickness of the twenty-one seams averaging 108 feet.

The general strike is north-west and south-east, dip south-west, and outcrops are visible over a great extent of country. Fire-damp is, so far, unknown in the district, wherefore gunpowder is freely used for shot-firing. The strata

covering the Coal-measures are often very wet, and consequently inrushes of water into the workings constitute one of the chief dangers to be guarded against. Lignite-deposits occur in the Keuper (Trias) of Bendzin.

From 70,000 tons or thereabouts in 1855, the annual coal and lignite-production in Poland has risen to roughly 2½ million tons in 1891. Good hauling and pumping-engines and picking-screens are in use at all the collieries, and coal-washing apparatus at most of them. The larger number of pits communicate by branch railways with the great main line from Warsaw to Vienna.

On both the eastern and western slopes of the Urals, Coal-measures occur. Those on the European side resemble, by their intercalation between the Lower Carboniferous and the Devonian Limestones, the Coal-measures of the Moscow basin, but there the resemblance ceases. In the Urals, the coals are true coals, and not lignites and boghead as in the Moscow seams. On the Asiatic side are coals of various quality, also anthracites, graphitic coals, and graphites; and it was on these eastern slopes that the Ural coal-mining industry was at one time concentrated. It has now, however, migrated from the eastern to the western slopes. The average annual production is roughly a quarter of a million tons, mostly from four mines. The annual production of coke does not exceed 9,000 tons.

The Caucasus coals are of little industrial importance so far. In 1891, one mine was being worked in the Tkvibul deposits (30 miles from Kutáis) producing barely 7,000 tons. In the Northern Caucasus the Jurassic coals and bituminous shales of the Kuban district have been worked for well nigh fifty years.

The Kuznetzk basin in the south-east portion of the government of Tomsk (Western Siberia) is limited by the Saláir and Alatáu mountain-ranges, and cut in two by the river Tom. The area of the coal-field is close on 11,000,000 acres, and at many points thick seams of excellent quality have been proved, varying from 3 to 40 feet. The coal-bearing strata are of Jurassic age. In 1891, only two mines were so far at work, producing annually about 18,000 tons; but the quantity of available coal is estimated in millions of tons. Most of the coal got at present is used for the treatment of metalliferous ores in the Altái district.

In the Kirghiz Steppes are Carboniferous strata, with coals of various quality, lignites, and bituminous shales. Very little has been done to develop the mining industry there so far. Coal also has been proved at many localities in Eastern Siberia and Kamchatka. Especially noteworthy are the series of coal-deposits of the island of Saghalien, extending along the western coast for 590 miles, as well as along the eastern coast and inland. These coals are of Tertiary age, and nevertheless are said to vie in quality with the best Welsh coal. The seams rarely exceed 3 feet or so in thickness, and are worked by adits cut within the seam. The Saghalien coal is supplied to the Russian fleet in the Pacific, to foreign men-of-war and merchantmen, and the production is increasing to keep pace with the demand. One disadvantage is the distance of the coal-workings from the harbour of Vladivostok, and since 1886 the Imperial Government have organized a systematic search for coal on the mainland (maritime or seaboard province of Eastern Siberia). The best results are reported from the Suchan river, where is a seam, from 3 to 6½ feet thick, with coal of good quality, resembling in some respects that of Cardiff.

In Turkestan, coal was already known before the Russian annexation. Since then, further search has been made, with the view of supplying the flotilla on the Sea of Aral, and deposits are now being worked around Chimkend, Tashkend, and Khodjend. Some of the seams are 16 feet thick. In 1891, there were six mines at work, producing annually about 8,000 tons.

13. *Salt.*—Some 43 miles south of Orenburg is one of the most extensive rock-salt deposits in the world, that of Iletzkaia-Zashtita: there the rock-salt, very free from impurities, forms a mass at least 2 miles long and 425 feet thick, the estimated amount of possibly available salt exceeding 250 millions of tons. It belongs to the State, but is leased for mining purposes to private individuals. At Chapchachi, in the government of Astrakhan, is an equally enormous mass of rock-salt. In 1876, the Bakhmut-Brianzevka deposit in the government of Ekaterinoslav was proved: borings showed a thickness of 340 feet of pure salt. Rock-salt deposits are also worked at various localities in Transcaucasia and in the Transcaspian province.

A large number of brine-springs are pumped and the brine evaporated in various parts of Russia-in-Europe and in Eastern Siberia.

Salt lakes are very numerous in the Empire, and are scattered over a vast area. Among these may be mentioned Lake Elton (49,400 acres in extent), 185 miles from Saratov, on the left bank of the Volga, and Lake Bashkunchak (27,570 acres), besides seven hundred smaller lakes in the government of Astrakhan, dotted over the low-lying Arato-Caspian plain. In Lake Bashkunchak are three separate layers of salt, the uppermost of which alone represents a mass of more than 750,000,000 tons: a branch railway facilitates communications with the Volga.

In the Crimea, the salt-lakes are cut off from the sea by a very narrow strip of dunes, and the amount of salt harvested from them depends on the relative humidity of the seasons. Salt-lakes also occur in the governments of Stavropol and Kherson, in the country of the Don Cossacks, and in various provinces of Siberia.

The total annual production of salt averages 1¼ million tons (in 1891), the number of workpeople employed being 19,500. The excise duty on salt was abolished in 1881, but there is still a Customs duty on foreign salt of about 38 shillings a ton, except in the harbours of the government of Arkhangelsk, where the duty is only one-half of that amount. Glauber's salts are got from some of the lakes of the Caucasus and of Western Siberia, in all about 8,000 tons annually.

14. *Petroleum.*—The countless deposits, rich in petroleum, that occur in the Russian Empire are at once divisible into two categories: the first includes those deposits which are dispersed like islets amid the sea of surrounding strata, and the second those which cover vast continuous areas. Under the first heading come the Ushta River (Arkhangelsk) deposits, the Soké River (Volga) deposits, those of Kielce (Poland), of the provinces of Uralsk and the Turgái, of Turkestan and Saghalien Island. In none of these has much exploring work been done: indeed, they are so far all but unworked.

To the second category belongs the great petroleum-wealth of Russia, concentrated chiefly along the northern and southern slopes of the Caucasus, and in the governments of Elisabetpol, Tiflis, and Kutáis, the richest area of all being the peninsula of Apsheron, which runs out far into the Caspian Sea. East of that sea, moreover, in the Transcaspian province, rich oil-wells have been tapped. The author sketches the history of the development of the petroleum industry at Baku, etc., showing that its marvellous extension is of quite recent date, the deadening system of monopolies having been abolished only in 1872. The excise duties on the oils (higher per cwt. for light than for heavy oils) do not appear to have any deterrent effect, and they bring into the coffers of the Imperial Treasury over £1,000,000 yearly.

The annual production of petroleum in the Russian Empire increased from about 820,000 tons in 1882 to 4,700,000 tons in 1891, that is, it was nearly sextupled in the course of a decade; and the annual output of petroleum-derivatives was nearly quadrupled.

An observation which appears to confirm the geologist's view of petroleum-deposits, and tends to show that their probable limit of exhaustion is not so very remote, is that the petroleum has year by year to be sought for deeper and deeper down, while the average output per borehole becomes smaller and smaller; the average depth of borehole, which in 1881 was 420 feet, rose to 748 feet in 1891. The quantity produced by spouting (or artesian) wells has diminished in recent years by about 50 per cent.

Within the Russian Empire, the use of petroleum and its residues for firing the boilers of railway-engines, steamers, and factories, and even in the processes of iron-manufacture and copper-smelting, has greatly extended. Nor is it necessary to mention that imports of American petroleum are now reduced to vanishing-point. The financial result is that whereas Russia expended in 1873 about £1,050,000 on foreign petroleum, she received in 1891 more than £3,000,000 for her own petroleum: Turkey, Austria-Hungary, and Great Britain being her largest customers.

15. *Asphalte* is got from sandstones and limestones in the district of Syzran, government of Simbirsk, on the right bank of the Volga, and, under the name of *kir*, it is worked in the Caucasus.

16. *Sulphur.*—No detailed exploring work has been done in any of the Russian deposits. Near Sukéev, government of Kazan, on the Volga, sulphur is found in nests, and small agglomerations and bands in Permian limestone. The single refinery established there is now closed. Near Charkovo, government of Kiela, Poland, sulphur occurs abundantly, disseminated in Tertiary marls. There, too, a refinery has been established, and was at work in 1885, but has been closed within recent years. A new deposit has lately been discovered in the neighbourhood.

In the Caucasus, sulphur has been found at several localities in either side of the mountain range. Near Chirkat, province of Daghestan, a sulphur-deposit in the Upper Jurassic rocks is worked by a French company. Many other deposits are reported in the same province, and in the governments of Tiflis and Erivan.

Within recent years the discovery has been made of a very rich sulphur-deposit in the Transcaspian province, about 150 miles from Geok Tepé and Khiva; the amount of available sulphur is believed not to fall short of half a million tons.

So far, however, the total output of sulphur in the Russian Empire is exceedingly small, and large quantities of raw sulphur are imported from Italy, and of refined sulphur from France.

17. *Graphite.*—The famous deposits in the government of Irkutsk are now worked on a very limited scale, just sufficient to provide the Irkutsk gold-foundry with crucibles. The deposits discovered in 1860 in the north of the government of Yeniseisk, along the rivers Nijnaya-Tunguska and Kureika, are of excellent quality, and are being worked.

18.—The phosphate-deposits, building-stones, precious minerals, and thermal springs of the Empire are all briefly noticed; but the author has little that is new or of general interest to say about them. The appendix to the paper contains preliminary and incomplete mineral statistics for the Russian Empire in 1892.

O. S. E.

PREHISTORIC MINING IN THE ASTURIAS, SPAIN.

Las antiguas minas de cobre y cobalto del Aramo. By Alfonso Dory. *Revista Minera*, 1893, *vol. xliv., pages* 333-7 *and* 361-6, *and* 3 *plates.*

The Sierra del Aramo, on the eastern slope of which the entrances to the prehistoric workings are found, is a spur from the main Cantabrian chain, attaining an elevation of over 5,500 feet above sea-level. It is a mass of Carboniferous Lime-

stone separating the basins of Mieres to the east and Quirós to the west. The workings are situated about half-way up the mountain.

When discovered in September, 1888, by Mr. van Straalen, the entrances consisted of narrow vertical chimneys, intended to prevent the escape of the slaves working within. In laying bare the rock for the foundation of the buildings for the present working, beneath successive layers of earth and clay numerous tools and other traces of human occupation were discovered. Moreover, near the village of Llamo, about ½ mile distant, considerable quantities of very homogeneous slag are met with, indicating that some sort of continuous furnace must have been used. The use of many of these tools is doubtful; some, however, were possibly used to crush and pulverize the ore. Small crucibles of clay, mixed with powdered quartz, have been met with. These sometimes contain fragments of partly-reduced ore, and are probably of earlier date than the furnaces above referred to.

Among the objects discovered in the workings may be mentioned sixteen skeletons, mostly of good stature, two of which are complete; stone hammers; horn picks; stone wedges; torches; two wooden bateas; a knife of bone (apparently human); a carved nut, etc. The skeletons, which are stained green with copper, appear to be those of young men. Examination, both of the crania and the method of working, suggests the succession of two distinct races. Some of the horns found refer to species which are extinct, entirely or in this region.

At the junctions of certain galleries a cross is traced, together with two horizontal parallel lines; these are referred to the second race of workers, and were possibly used as guide-marks. In another place a mass of white limestone is erected on a rough pedestal, so as to be visible from some distance, doubtless for the same purpose. There are traces of fire-setting having been used on a large scale to loosen the rock.

The clay which fills the cavities of the rock was scraped out by the workers' hands—this being shown by its containing thousands of impressions of all sizes, from that of a small boy's fingers to double the size of an ordinary man's thumb. In some places pillars are left, while in others masses of rock are piled up to support the roof.

Some of the galleries, driven in compact limestone, are so narrow that a man of average height can hardly squeeze through them, a fact which leads the writer to conjecture that the workers must have been excessively thin. In places the rock is polished by the circulation of the workers. In the inclined winzes there is no trace of steps or ladders; there is sometimes, however, a hole pierced in the rock near the top, from which a leather rope may have been suspended. The wooden *bateas*, one of which has a leather thong as handle, were doubtless used to convey the ore.

The width of the veins so far discovered varies from 1 to 6½ feet, the ores present being copper and cobalt. The former exists as black oxide, of from 15 to 25 per cent., coated with a skin of blue or green carbonate. The cobalt—also oxide—is black, hard, and compact, somewhat similar in appearance to the copper. It is disseminated through the dolomite walls, and especially near the cavities. The great regularity in direction and dip of the veins leads the writer to suggest that they were formed by the transformation of the limestone into dolomite bands by magnesian solutions, followed by others which deposited copper and cobalt in the cracks in the latter.

Particulars are added of the mineralogy and metallurgy of cobalt, especially the Herrenschmidt and Schœneis processes, and the paper concludes with an estimate of the commercial value of the deposits, which is considered to be very great. G. E. C.

EXTRACTION OF ORE FROM WIDE VEINS OR MASSES.

By G. D. Delprat. *Transactions of the American Institute of Mining Engineers*, 1892, *vol. xxi.*, *pages* 89-101.

The cross-cut system of mining is described, as carried out at the Cabezas del Pasto copper mine in the south of Spain, as opposed to the more common method of pillar-and-stall-workings, over which the writer claims several advantages.

The upper portion of the lode consists of gossan for a depth of 100 feet, composed of a siliceous peroxide of iron mixed with clay. The copper has been dissolved out and filtered into the undecomposed ore below, which is found to contain less copper with depth.

In the pillar-and-stall method, the lode is divided into floors about 35 feet apart, of which 12 to 15 feet has to be left as roof, besides pillars 15 to 20 feet square, so that only about one-half the ore can be extracted, while in the cross-cut system all the ore is extracted. At first two shafts are sunk, one for raising the ore, and the other for lowering the stowing material. The lode is 500 feet long, with an average width of 32 feet, and is divided into floors 65 feet apart, each floor being connected to the shaft by a cross-cut. When these cross-cuts have reached the lode, narrow galleries are driven, following the hanging-wall, to prove the shape of the mass. After this straight side-ties are driven for the more convenient tramming of ore to the cross-cuts and thence to the shaft.

Roads 6 feet square are now driven right through the lode to the foot-wall, at distances of 33 feet from each other. These are packed with stone, and other similar ones driven by the side of them or practically widened off the original road. This goes on until the stalls meet with the adjoining narrow road originally driven 33 feet away; thus the whole width of the lode is removed for a height of 6 feet.

The narrow gallery previously mentioned is then packed and another one started right above it, still following the wall of the lode, after which roads are again driven to the foot-wall exactly above the first ones, the only difference being that in driving the first roads the ore was solid, while in the second ones it is undercut and rests on the packing of the first.

The price paid per ton of ore for the first slice averages 2s. 1d., and in the first road, before the widening off had commenced, 3s. 1d., as opposed to 1s. and 1s. 9d. respectively when the lode had been undercut.

Slice succeeds slice until the floor above is reached, and here the packing has become so tight that no difficulty is met with. After the first slice has been removed the ore is thrown down chutes—carried up in the packing—into the cross-cut below, and thence trammed to the shaft.

The material used for stowing is quartzite and is quarried on the surface and lowered in hutches down a special shaft by means of double drums fitted with brakes: the loaded tubs pulling the empty ones up.

Each level is supplied with stone from the floor above by means of winzes made in the hanging-wall. Only large stone is used, as the small is much more expensive to handle down the mine and settles down so much when packed as to loosen the ore above and cause a treacherous roof.

The average quantity of ore broken by a miner is 3 tons per shift of 10 hours, as opposed to ⅓ ton in the pillar-and-stall method. The average cost per ton, apart from general expenses, is 2s. 11d., and for stowing 1s. 8d. per cubic yard, which is equal to about 2½ tons of ore extracted. The cost per ton in the pillar-and-stall method averages about 4s. A. W. G.

THE SYSTEM OF FILLING AT THE MINES OF THE MINNESOTA IRON COMPANY, SOUDAN, U.S.A.

By D. H. Bacon. *American Institute of Mining Engineers*, 1892, *vol. xxi., pages* 299 *to* 304.

The ore deposits occur in lenses, 200 to 1,000 feet long by 5 to 80 feet wide, lying at an angle of about 70 degs., with a vertical height of 250 to 500 feet.

The method consists in sinking a shaft in the country-rock with levels every 75 feet. Cross-cuts are carried in from the shaft, and the ore is worked each way from the shaft from foot to hanging-wall, and 15 to 20 feet high.

When this has been done, drift-sets consisting of cap and legs are set up the whole length of the opening, and connected with the cross-cuts. The necessary openings for ladder-ways and chutes are timbered, 5 feet square, from the floor to a few feet above the top of the drift-sets. Loose rock is then run in, until about 4 feet of loose rock is above the timber; then 10 feet of the roof is blasted down and more filling is let in, the ladder-ways, etc. being cribbed up. This is continued till the level above is reached. Raises, for filling, are driven in the foot and hanging-wall close to the ore, from level to level. In winter, when the rock at the surface is frozen, filling is obtained from the first level, or blasted down from the walls.

Several advantages are claimed over the system described by Mr. G. D. Delprat,* the chief of which are, that the expense of lowering the rock is avoided, and fewer rock-drifts or cross-cuts are required. A. W. G.

NOTES ON THE LEASE- OR TRIBUTE-SYSTEM OF MINING, AS PRACTISED IN COLORADO, U.S.A.

By B. B. Lawrence. *American Institute of Mining Engineers*, 1892, *vol. xxi., pages* 911-919.

The lease-system is becoming much more general as its advantages become better known.

The working of mines by corporations has often been attended with disaster, owing to the difficulty of securing a fair day's work from the men, the loss entailed by careless mining and sorting of high-grade ores, or by inefficient management.

All of these disadvantages can be in a great measure overcome by giving the men a stake in the mine, which is the main point in this system.

An owner through the causes mentioned above is unable to work his mine at a profit. He divides it up into a number of small leases, which are taken up by the men on the payment of a royalty upon the mill returns of the ore which they get. By dividing it up into blocks of ground, varying from 50 to 100 feet in length, and determined in height by the distance between the levels, each lessee is left to work his own particular block of ground, the ore being kept separate, and when delivered on the dump, becoming the property of the lessor or owner of the mine.

The ore is then shipped to the nearest sampling-works and its value ascertained, the lessee paying the cost of the control-sample.

The lessees are under the full control of the foremen, just as though they were working for day wages. The owner thus developes his mine at little or no cost to himself, the lessees driving levels, sinking winzes, etc., etc., in order that they may open up stoping ground. It is evident that under this method the owner takes little or no risk, and is assured of profit if ore be found. A. W. G.

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* *Trans. Fed. Inst.*, vol. ix., page 513.

NITRATES IN EGYPT.

ANON. *The Engineering and Mining Journal (New York)*, 1895, *vol. lix., page* 81.

The report of the Commission to the Egyptian Council of Ministers dealt with the nitrate-bearing clay in Upper Egypt, which contains nitrates equal on an average to 15 per cent. of sodium nitrate. The supply is stated to be practically inexhaustible. Situated 470 miles (760 kilometres) south of Cairo, on the eastern bank of the Nile, are low ranges of hills at the foot of the principal range of limestone cliffs. These foothills were examined for a length of 15 miles, and are formed of nitrate-bearing clays, with a thin cap or covering of limestone. The clay is used by cultivators, locally, as a fertilizer. The clay is supposed to occur over an area stretching from 24 to 27 degs. north latitude, and from 28 to 34 degs. east longitude. Without the use of this *marog*, agriculture would be at a standstill between Assuan and Armant. The following analyses of *marog* were made by Dr. Mackenzie at the Tewfikieh College :—

Samples.	No. 1.	No. 2.	No. 3.	No. 4.
Moisture (dried at 212 degs. Fahr.)	2·44	1·83	3·42	2·68
Silica	19·34	10·37	22·56	22·81
Carbon dioxide	14·77	8·43	7·02	5·92
Phosphoric acid	0·57	1·72	0·29	0·27
Sulphuric acid	3·82	9·87	7·13	6·87
Nitric oxide	9·40	9·94	8·82	11·77
Chlorine	4·90	12·62	6·31	6·31
Iron oxide	4·37	4·37	5·65	5·27
Alumina	11·03	6·88	12·94	12·99
Lime	18·90	16·31	13·36	11·51
Magnesia	0·67	1·13	1·12	0·90
Potash	0·10	3·45	0·18	0·21
Soda and combined water (by difference)	10·74	15·77	12·55	13·84
Totals	101·05	102·69	101·35	101·35

J. W.

NYSTAGMUS, THE EYE-DISEASE OF COAL-MINERS.

Der Nystagmus der Bergleute. By DR. L. C. *Glückauf*, 1893, *page* 1391.

Nystagmus appears to have been first known about 1860, and it has been noticed that it has increased since then in all coal-mining countries. The principal symptom of the disease is that the miner, after a long shift, finds his sight unsteady, and his light appears to be in continual movement. A short interval of rest is sufficient to remove this unpleasant sensation. When the disease is more acute, the miner is attacked at his work, and finds that he cannot see to hold his tools; he has headaches; and, finally, cannot walk straight. Any attempt to see things by ordinary light above the horizontal level brings on the nystagmus. In one district, Dr. Nieden examined 11,145 men, and found that 3·6 per cent. suffered from nystagmus. The proportion between those coming from work and those going to work was as 4·1 to 3·1 per cent.

All those who have studied the subject agree that the disease is confined to those men who mine the coal, and who lie cramped up in a lying position, very often having to look upwards. The muscles of the eye cannot bear the excessive strain, which is aggravated by the poor quality of the light. It has been noticed that nystagmus is much more frequent in mines where safety-lamps are used than it is in mines where there are naked lights. As evidence of the important part that the quality of the light plays in connexion with the disease, it is said that at the Rhein Elbe collieries in 1877, when naked lights were used, 0·7 per cent. of the men suffered from nystagmus; three years later, after safety-lamps had been introduced, the percentage rose to 3·05.

The author has no doubt that the introduction of a better light in mines would reduce the disease. W. F. W.

A TEST FOR CYLINDER OILS.

Anon. *The Engineering and Mining Journal (New York)*, 1891, *vol. lii., page* 570.

Mr. T. H. Macdonald, chief engineer of the California Electric Light Company, San Francisco, has furnished some data respecting the quantity of oil used for internal lubrication of the engines at their Townsend Street Station. The areas given are square feet of surface moved over; that is, the internal surface of cylinders and valve-faces multiplied into velocity, as follows:—

I.—700 Horse-power Compound Reynolds-Corliss Engine.

20 inches and 33 inches by 48 inches, 83 revolutions.

		Square Feet.
Valve-surfaces	multiplied into velocity =	400
Surface high-pressure cylinder	,, ,, ,, =	3,476
Surface low-pressure cylinder	,, ,, ,, =	5,710
Total area oiled with 1 drop per minute		9,586

The engine was lubricated with one drop in two minutes with good results, showing a surface of 19,172 square feet by one drop of oil, but it is considered advisable to feed one drop per minute.

II.—600 Horse-power Compound Slide-valve Engine.

20 inches and 36 inches by 36 inches, 143 revolutions.

		Square Feet.
Valve-surfaces	multiplied into velocity =	437
Surface high-pressure cylinder	,, ,, ,, =	4,487
Surface low-pressure cylinder	,, ,, ,, =	8,065
Total area oiled with 2 drops per minute		12,989

or 6,494 feet for one drop of oil. The feed on this engine was cut down to 4 drops every three minutes, or 9,742 square feet lubricated with 1 drop.

This indicates the marvellous viscosity of good oil, and, as a method of gauging the lubricating power of oils by the surfaces maintained, is new and commendable. Any engineer can count the drops of oil, calculate the area of the surfaces and multiply them into speed, and compare the results with the statements of agents for oils, which latter are often, of course, exaggerated. Apparently, there never has been, previously, a method capable of general use for arriving at any kind of measure of the efficiency of lubricating-oils. J. W.

PETROLEUM IN SOUTHERN STYRIA, AUSTRIA.

Notiz über ein Petroleum-Vorkommen in Südsteiermark. *By* Dr. J. Dreger. *Verhandlungen der k. k. geologischen Reichsanstalt, Vienna*, 1893, *page* 287.

A small quarry, opened in the grey Upper Miocene sandstone of Friedau (Lower Styria), showed rock permeated and brownstained with bituminous matter. The burgomaster had reported the existence of a "petroleum spring," but the occurrence is, at any rate, quite local. The author found here fragmentary remains of a *Clupeus*, and he seems to infer that the petroleum originates from slow distillation of fossil marine organisms *in situ*. O. S. E.

PETROLEUM IN ALSACE, GERMANY.

Das Vorkommen von Erdöl im Elsass. *By* Dr. Jasper. *Glückauf*, 1895, *vol. xxxi., pages* 215-218.

The author has had in his official capacity during the last 12 years ample opportunity for watching the development of the petroleum industry in Upper and Lower Alsace. Art. 1 of the Mining Law of December, 16th, 1873, enumerates bitumen (petroleum, mineral wax, etc.) among the minerals which are excluded from the landowners' proprietary rights, but for which mining concessions are granted by the State, and the necessary ground for working them may be compulsorily obtained. In practice, friction between the landowners and the mine-owners is rare, for the parties generally come to an amicable arrangement.

The first exploration for bitumen appears to have been made at Pechelbronn somewhere about 1745, and here workings for petroleum as well have continued down to our own days. An extraordinary outburst of activity took place in 1889, and borings were put down in every direction, through the Tertiary and Mesozoic rocks, to depths varying between 165 and 985 feet; they yielded a thick viscid crude oil of a brownish-black hue. The bituminous deposits, so far proved by 13 shafts and 700 deep borings, form a belt 25 miles long and 9 miles broad, ranging parallel with the Vosges; but there is reason to believe that the productive area will be found to occupy a much vaster extent of country. Especial reference is made in this connexion to the fish-bearing shales of the Altkirch district in Upper Alsace, which are distilled for oil, and correspond in geological position with the fish-bearing shales of Galicia; so that here, too, a natural reservoir of petroleum will probably be tapped below the shales. In Alsace generally, the bituminous bands are associated with the upper portion of the Lower Oligocene Marls. These are now known to be nearer 2,000 feet than 1,000 feet in thickness (as was formerly supposed). The attempt to work the bitumen and petroleum in underground workings by means of shafts was finally given up in 1888. Constant inflows of sand and brine, blowers of gases, accompanied by floods of petroleum oil, had invaded the workings at frequent intervals. Boring and pumping are the only methods now in use.

The physical and chemical properties of the Alsatian petroleum are as follows: – Its consistency (thickness) varies from place to place, and its colour from brown to black. The specific gravity is 0·82 to 0·95 at 32 degs. Fahr.; and boiling points range between 275 degs. and 302 degs. Fahr. Its percentage composition varies from 80 to 85 of carbon, 10 to 12 of hydrogen, 0·5 to 4 of oxygen, and 0·134 to 0·138 of sulphur. Moreover, it contains a good deal of paraffin, which separates out from it on reduction of temperature. The products derived from the crude oil may be classified as under:—2 to 3 per cent. of benzine and ligroine, 30 to 35 per cent. of

illuminating oil (petroleum, kerosene), 40 to 45 per cent. of residues (lubricating-oil, tar, gas-oil, paraffin-oil, vaseline), 10 to 15 per cent. of coke. The crude oil from the borings is pumped to the refineries of Pechelbronn and Sulz through a system of pipes laid in the earth over distances of respectively 3 and 4½ miles. In other localties similar pipes convey the oil to railway-stations, whence it is shipped in tank-waggons to various refineries in the Rhine Palatinate.

In pumping and boring all the newest appliances are used, preference being given to the Fauvelle system, the Canadian boring process, and the Raky system.

The annual production of petroleum in Alsace has steadily increased from 845 tons in 1878 to 15,632 tons in 1894. As before hinted, a much greater extension in the future may be looked for, and the author hopes to see Alsatian petroleum enter into active rivalry with the Russian and American oils for the supply of the inland trade in the German Empire. At present it only bulks for about 1·3 per cent. in this trade. O. S. E.

PETROLEUM WELL AT OBERKUTZENHAUSEN, ALSACE, GERMANY.

Note sur le Sondage d'Oberkutzenhausen, près Pechelbronn. *By* M. Mieg. *Bulletin de la Société Industrielle de Mulhouse,* 1895, *pages* 107-114.

This boring, the work of the Société des Mines de Pechelbronn, is 1,670 feet (509 metres) in depth, and is lined with pipes decreasing in diameter from 15 inches at 54 feet below the surface to 5 inches at the depth of 1,621 feet (494 metres). Operations were performed solely with the freefall boring-apparatus. Down to a depth of 1,181 feet (360 metres) the boring passes through alternate layers of grey or greenish clay and siliceous sand, more or less impregnated with bitumen, and below these for a further 330 feet coloured and variegated clays, the detritus of Lias and Keuper rocks, are encountered. The petroleum stratum, a bed of sand about 3 feet in thickness, yielding, when pumped, 1½ tons of oil per diem, was struck at 1,097 feet (334½ metres), and at a further depth of 538 feet (164 metres) a brine-spring containing 8 per cent. of saline matter was tapped. This spring is artesian, and yielded at first 15,000 gallons of water daily, but the quantity has since decreased to 2,000 gallons. The water, like that of the Pechelbronn brine-springs, is rich in chloride (salt) and bromide of sodium, of which latter substance it contains up to 11·1 grains per gallon, and sulphates of lime and magnesia are also present. Curiously enough the temperature of the water is only 81 degs. Fahr., while that of the earth at 1,611 feet (491 metres) below the surface is 104 degs. Fahr.

Observations taken by Messrs. Schützenberger and De Chambrier show that the increase of temperature with the depth in this boring, although not absolutely regular, is abnormally high, amounting to 41 degs. Fahr. for 895 feet, which corresponds to 1 deg. Fahr. for every 22 feet, or three times the usual amount.

In considering the geological aspect of the region, and reviewing the theories propounded to account for the formation of petroleum, the author is of opinion that the fossil *Cyrenæ* and minute *Limnæ* found in the alluvial strata indicate that brackish-water or fluvio-lacustrine conditions prevailed at the time of deposition. The synclinal basin of this oil-field resulted from fractures sustained by the chain of the Vosges, and was gradually depressed during the Lower Oligocene period, the alluvial clays and sands from the denudation of the Trias and Lias being deposited in inverse order to the antiquity of the original formations.

While the scarcity of brackish or fresh-water fauna and the complete absence of marine fauna capable of producing the important accumulations of animal remains necessary, according to Prof. Engler's theory, for the production of petroleum, prevent us from affirming that the essential conditions on which the theory is founded are here met with, still the author considers that Prof. Engler's affords a better explanation of the formation of the Pechelbronn petroleum-beds than any of the other theories yet advanced. C. S.

PETROLEUM IN BURMA.

Note on the Chemical Qualities of Petroleum from Burma. *By* Prof. Engler. *Records of the Geological Survey of India*, 1894, *vol. xxvii., pages* 49-53.

The petroleum examined came from the following localities:—(1) Yenangyat; (2) Kodoung; (3) Twingon; and (4) Minbu.

It was examined chiefly with regard to specific gravities and products of fractional distillation.

The samples consist chiefly of hydrocarbons of the paraffin group (C_nH_{2n+2}), naphthenes occurring in small quantities only. The oil from Minbu is an exception, containing a large quantity of naphthenes. The composition of the different oils is as follows:—

	Light Oils (below 302° Fahr.).	Illuminating Oils (302° to 572° Fahr.).	Lubricating Oil and Paraffin Wax.	Difference and Loss.
Yenangyat ...	17·8 vol. % ...	49·4 ...	30·8 ...	2·0
Do. ...	18·6 ,, ...	49·6 ...	28·3 ...	3·5
Kodoung ...	4·3 ,, ...	38·8 ...	50·4 ...	6·5
Twingon ...	5·5 ,, ...	38·8 ...	48·7 ...	7·0
Minbu	— ...	— ...	76·7 ...	21·3

Hitherto the author has never met with oils of like consistency containing so high a percentage of illuminating-oil. G. W. B.

THE PETROLEUM INDUSTRY OF THE UNITED STATES.

L'Industrie du Pétrole aux Etats Unis d'Amerique. *By* Messrs. Riche *and* Roume. *Annales des Mines*, 1894, *series* 9, *vol. v., pages* 67-130, *and plate II.*

The authors were sent on a Government mission to the United States in the year 1892 by the French Minister of Commerce and Industry, and the data which they collected are presented in this paper with such clearness and conciseness that it may prove valuable even to the English reader. The first chapter contains a fairly complete summary of the chief occurrences of natural gas and petroleum in the States, together with statistics of production, number of wells, densities of oils, etc. The second chapter gives an account of the processes of refining the crude oil in use at the Bear Creek Company's factory near Pittsburgh, and at the Standard Oil Company's factories at Bayonne (New Jersey) and Whiting (Illinois), and the American processes are compared with the French, to the disadvantage of the latter. It is pointed out that the French refiners attempt by excessive heating to destroy the residual heavy oils and paraffin, so as to transform them into illuminating-oils; but these illuminating-oils are of so low a grade that they

deteriorate the good oils with which they are mixed for market purposes. The third chapter gives an account of the industrial applications of petroleum to purposes other than lighting or manufacture of lubricating-oils. A map of the petroleum and natural-gas region of western Pennsylvania accompanies the paper. O. S. E.

THE KEROSENE SHALE OF NEW SOUTH WALES.

Sur la Reinschia australis, algue permo-carbonifère qui a formé le Kerosene-Shale d'Australie. By C. Eg. Bertrand *and* B. Renault. *Association française pour l'Avancement des Sciences, Compte-rendu de la* 22ème *session* (*Besançon* 1893), *part* 2, *pages* 490-502.

The Australian kerosene shale or boghead is of Permo-Carboniferous age ; it is very light (its specific gravity ranging as low as 1·05), very homogeneous, has a conchoidal, satiny fracture, is blacker than the Torbane Hill mineral, but of a duller black than Autun boghead. Flattened imprints of plants (*Glossopteris*, etc.) occur in it, and trunks of *Vertebraria* are recorded as being found erect in the shale at Joadja Creek. These tree-trunks are partially, and in some cases wholly, altered to jet : the authors think that the trunks are not *in situ*, but are driftwood impregnated with bituminous matter, such as the thelotite of Autun. On long exposure to the atmosphere and to rain, the more impure portions of large specimens of the shale assume a reddish tinge, and the laminæ of bedding then become visible.

The kerosene shale is the second known example of boghead almost entirely made up of an accumulation of gelatinous algæ in an ulmic precipitate. The structure of the alga is still recognizable, and the authors give to the species the name of *Reinschia australis*. It is calculated that a thickness of about 4 feet of the deposit represents 36,000 individual layers of algæ. The specimens examined enable the observer to trace the entire life-history of *R. australis*, through all its various stages of growth, from the young thallus to the adult ; descriptions of the structures and measurements are given in full detail in the original paper. The transformation of the thalli into gum-like amorphous masses is noted, and attention is drawn to the fact that structureless yellow globules are the ultimate representatives of the thallus of a gelatinous alga. The remark is of importance in view of the study of the "yellow bodies" observed in coal. It is true that in the same shale empty and broken spore-cases give rise to another kind of "yellow body." The chemical composition of some layers of the kerosene shale differs from that of others ; it is demonstrable that this difference is connected with the variations in size and condition of the thalli of *Reinschia* forming those layers. Where the boghead seems purest, there the proportion of alga (as compared with the intervening ulmic precipitate and vegetable detritus) is predominant.

The authors conclude that the kerosene shale is a carbonaceous formation of the same type as the Autun boghead. Aquatic plants covered the surface of peaty pools, and rained down on the bottom where was accumulating the ulmic precipitate from those waters. Around the pools grew a cryptogamic vegetation, sufficiently abundant to give rise to showers of spores. Brown matter, of bituminous nature, clearly distinct from the ulmic products, commingled with the mass shortly after, or perhaps during its deposition. The rate of accumulation of the deposit was rapid. Unlike the Autun boghead, it contains no fish-scales, nor have the authors found in it any coprolites or siliceous nodules. O. S. E.

PHOSPHATE-DEPOSITS.

Bibliographie générale des gisements de phosphates de chaux. By X. Stainier. *Annales de la Société Geologique de Belgique*, 1893, *vol. xx.*, *Bibliographie*, *pages* 3-28.

This paper contains a list of works relating to phosphatic deposits for the following countries:—

Europe: Austria, Belgium, England, France, Germany, Italy, Norway, Portugal, Russia, Spain, Sweden; Asia: India, Palestine; Africa: Algeria, Tunis; America: Argentine Republic, Canada, Peru, United States; The West Indies; Pacific Islands.

The particulars for each country are given separately and in alphabetical order according to the name of the author. G. W. B.

PHOSPHATE-DEPOSITS IN SOUTHERN FRANCE.

Notes sur la nature et le gisement du phosphate de chaux naturel dans les départements du Tarn-et-Garonne et du Tarn. By Charles Helson. *Annales de la Société Géologique du Nord*, 1893, *vol. xxi.*, *pages* 246-265.

The introductory portion of the paper is devoted to a general description of natural phosphates of lime from the geological, mineralogical, and chemical point of view. Phosphate derived from bones is also touched upon, and the use of phosphates in agriculture is then dealt with.

In Tarn-et-Garonne the deposits were first discovered in 1862 on the Jurassic limestone-plateau above Caylus by the late Mr. Poumarède; but, although samples showed on analysis an equivalent of 70·64 per cent. of pure tribasic phosphate, no attempt was made to start workings until the end of 1870. Besides those near Caylus, important deposits occur in the neighbourhood of Bruniquel, Caussade, St. Antonin, and Montcéré (Tarn). British and Belgian prospectors leased some of the claims at extravagant prices, which in many cases swallowed up all the profits. In fact the deposits are only workable at a profit by chemical manure manufacturers, who deliver the prepared article besides extracting the raw material. This is due, as the author believes, to two main causes:—(1) The heavy royalty payable to the owners of the land, which is in some cases as much as £1 per ton of phosphate extracted. In others the royalty is 17s., in yet others 10s. and 8s., say on an average 13s. per ton. This royalty, however, is not due unless the raw stuff contains at least 70 per cent. of tribasic phosphate. If the "ore" is too poor, the lessee may either leave it or pay to the owner a compensation tax of about 4s. or 5s. per ton. The ordinary duration of leases is 10 years, which term may be extended by agreement. (2) The mode of formation of the deposits, which all occur on the surface of limestone-plateaux of middle Oolitic age. The phosphate is non-crystalline, generally pale and whitish in colour, sometimes tinged with grey, red, and yellow; the structure is concretionary. The phosphate fills pockets, clefts, and pipes which have evidently been produced in the limestone since the consolidation of that rock. It seems probable that the phosphate was precipitated from mineral waters containing abundant carbonic acid, whose presence increased their corrosive action on the limestone.

The observations made around Bruniquel and Caylus show clearly the distinct facies to which the deposits belong. For example, near Caylus, the irregular cavities or pockets filled with phosphate, which are often only a few yards across,

attain 65, 100, and even 115 feet in diameter. The bones and pebbles found in the pocket-deposits were evidently brought in from no great distance in some easily imaginable way, and their presence does not at all prove that the water in the "basins" constituted a medium which could sustain life. They show, however, that the deposition took place in the Tertiary period, and continued for some time during that period. Elsewhere the deposits are elongated "veins" with approximatively parallel vertical walls, which generally suggest infilling of rectilinear crevices. But these again are to be distinguished from the fault-fissure-veins, because they narrow very rapidly downwards, and surface indications are therefore extremely deceptive as to the mass of a deposit. Some of the deposits strike east-and-west, and another series crosses them at right angles, striking north-and-south.

The number of workings at present is small, for one thing, because in the desire to avoid competition and to monopolize for themselves the benefit accruing from recent discoveries, the present workers in the field have not bruited much abroad the fame of the Tarn-et-Garonne phosphates; and for another, because land-owners, tempted by speculative bids, have become more and more exacting in the matter of royalties, and have thus discouraged intending lessees.

Ten detailed chemical analyses are given showing respectively the following equivalents of tribasic phosphate:—85·72, 80·99, 80·34, 78·36, 76·62, 71·55, 69·79, 65·17, 62·43, and 58·07 per cent.

Not only in the neighbouring district is the phosphate used for agricultural purposes, but it commands a sale throughout a large portion of France.

In the same volume of the *Annales* is a translation by Mr. V. Vaillant of Mr. G. H. Eldridge's paper on the phosphates of Florida. O. S. E.

PHOSPHATIC CHALK IN THE NORTH OF FRANCE.

1.—*Note sur les gîtes du Phosphate de Chaux de Templeux-Bellicourt et de Buire.* *By* J. Gosselet.

2.—*Note sur les gîtes de Phosphate de Chaux aux environs de Fresnoy-le-Grand.* *By* J. Gosselet. *Annales de la Société Géologique du Nord*, 1893, *vol. xxi., pages* 2-10, 149-159, *with sections in the text.*

In the autumn of 1892, Mr. Gosselet visited the phosphate-workings of the district of Templeux-Bellicourt, situated near the boundaries of the departments of the Somme and the Aisne. They extend over an area, a little more than 3 miles long and ½ mile wide. At Villeret quarry is a section showing the grey chalk-with-phosphate intercalated in the white chalk: and in the former the amount of phosphate increases downwards, with a stratum of phosphate-nodules towards the bottom. It is inferred that these nodules were formed contemporaneously with the chalk. The workings are mostly in the phosphatic sand, which represents the residue from the dissolution of the chalk. Sometimes this sand occurs in horizontal layers on the surface of that formation (as at Les Hautes Bruyères), but most frequently it fills "pockets" in it, exactly like those known near Doullens. The author describes and figures a section at Templeux showing that chalk-rubble was formed from the white chalk at some period between the deposition of the phosphatic sand and the overlying Tertiary beds; the latter have here a line of green-coated flints at their base.

In the Buire district, besides phosphatic grey chalk (6½ to 9½ feet thick), and phosphatic sand, the nodules become so abundant as to form a kind of conglomerate, with an analysis showing 81·18 per cent. of phosphate of lime. It is

suggested that this conglomerate may be the result of a pre-Tertiary resorting or re-arrangement of the phosphatic chalk-beds. The "pockets" in the neighbourhood of Buire are much shallower than those worked at Doullens.

Near Fresnoy-le-Grand, at Montbrehain, phosphatic sand occurs in "pockets," which in very few cases go further down than the grey chalk; they are usually from 3¼ to 5 feet deep, and 15 inches in diameter. When they reach into the white chalk below, the surface of that rock is found to be coated with black clay.

At Fresnoy-le-Grand itself, the phosphatic grey chalk (5 to 6½ feet thick) is, like that at Villeret, observed to grow richer downward. Below it is a conglomerate (15½ inches thick) of phosphatic nodules in loose chalk, which passes into sand. Fossils are seen adhering to the surface of the nodules. The analyses appear to show that the nodules and the accompanying chalk-beds are very much poorer in phosphate of lime than the corresponding deposits at Buire.

At Méricourt, ½ mile south of Fresnoy quarry, the phosphatic chalk is again exposed, but here the conglomerate of nodules has in places thinned out, and in places completely disappeared.

Workings were just being begun at Étaves, and there the phosphatic sand-pockets in the grey chalk are overlain by Tertiary beds analogous to those seen at Templeux. The grey chalk is here 5½ feet thick, and is worked for phosphate as well as the sand.

[The detailed descriptions of all these occurrences, which are found in the original paper, together with the numerous diagrammatic sections in the text, will probably throw light on similar occurrences in other districts, and in view of the growing industrial importance of phosphate-deposits all over the world, no apology seems needed for devoting some space to the subject here.—Editor.]

O. S. E.

PHOSPHATIC NODULES IN THE LIAS OF LORRAINE, GERMANY.

Sur le Gisement et la Structure des Nodules phosphatés du Lias de Lorraine. By — Bleicher. *Bulletin de la Société Géologique de France*, 1893, *series* 3, *vol. xx., pages* 237-247, *and plate VI.*

After a brief reference to previous work on this subject, the author gives a table of the succession of the Liassic strata in Lorraine.

In the Lower Lias two horizons of phosphatic nodules occur, with casts of fossils, in marly limestones and sandy marls, but would not repay working.

In the Middle Lias there are four horizons of phosphatic nodules, three of which are worked in the department of the Vosges.

In the Upper Lias are marls with phosphatic nodules, which would not repay working. The uppermost beds are sandy marls with iron ores.

Where, as in the Vosges, it pays to work these phosphatic nodules, they are found lying heaped together loosely, freed from their matrix. Thus the compact ochreous limestone of the Middle Lias, which in Meurthe-et-Moselle protects the subjacent marls with phosphatic nodules from denudation, and thereby deprives them of industrial value, gives place laterally, as one approaches the department of the Vosges, to a sandy, easily-crumbling marl; whence the nodules are washed free and the deposits are "naturally concentrated." Near Ocelleville and Totainville there is a band of nodules, 12 inches thick, below 8 feet of ferruginous sandy marl overlain by humus. These 9 feet of deposits represent the residues of the "natural elutriation" of about 110 feet of strata.

A somewhat detailed description is given of the microscopic structure of the nodules, some of which are largely made up of casts of bivalves and ammonites,

others of fossil spongida, foraminifera, shell-débris, etc.; and attention is drawn to the dissimilarity which they exhibit to the phosphatic nodules dredged from great depths in the ocean by Dr. John Murray. They contain no manganese, nor have they a continuous ferruginous external crust. The nodules in the Upper Lias only contain 13·5 per cent. of phosphate of lime, and are generally smaller and more irregular in structure than those of the Middle and Lower Lias. None of these Lorraine nodules bear any resemblance to coprolites. O. S. E.

PHOSPHATE-DEPOSITS IN ALGERIA.

1. *Description géologique de la région des phosphates du Dyr et du Kouif, près Tebessa.* *By* — Blayac. *Annales des Mines*, 1894, *series* 9, *vol. vi.*, *pages* 319-330, *and plate XV.*
2. *Note sur les lambeaux suessoniens à phosphate de chaux de Bordj Redir et du Djebel Mzeita.* *By* — Blayac. *Annales des Mines*, 1894, *series* 9, *vol. vi.*, *pages* 331-337.

North-east of Tebessa, a few miles from the Tunisian border-line, are two outliers of Suessonian (Lower Eocene) limestones, rising as table-shaped hills some 2,500 feet above the plain; these are Jebel Dyr and Jebel Kuif. There is a third outlier, Ain Kissa, let down by faults south of the first, and phosphate workings have just been started in it.

The author describes briefly the succession of Cretaceous and Eocene strata observed in these hills in ascending from the plain to the summit. The Lower Eocene consists of black and grey marls at the base, overlain by marly limestones with siliceous nodules and phosphate-bands, and these in their turn are capped by hard compact limestones, containing *Nummulites* and *Thersitea*. The Eocene here is lying in two synclinal folds of *Inoceramus* limestones.

The marls have at their base at Ain Kissa a band, 27 to 31 inches thick, of phosphate of iron, with selenite-crystals and sharks' teeth. This band appears to occur at no other locality, but the marls are slightly phosphatized throughout, and make excellent arable soil.

In the marly limestones at Jebel Dyr are three beds of phosphate of lime, the lowest being about 10 feet thick, the next 2 feet, and the highest 20 inches thick. The 10 feet bed is highly siliceous in its upper portion, and this hard, siliceous part is used as a roof for the workings. The average percentage of phosphate in the rock that is mined varies between 60 and 75. The two other beds are not worked; followed westward, they are seen to join, and then to thin out altogether.

At Jebel Kuif there is only one bed of phosphate between the black marls and the upper limestones, but it is $14\frac{3}{4}$ feet thick, and at least three-quarters of this thickness is workable. Some of the softer portions average as much as 78 per cent. of phosphate. At Ain Kissa there are as many as six separate bands of phosphate interstratified with the marly, siliceous-nodule-bearing limestone, but they cover a comparatively small area, being largely cut out by the numerous faults which have dislocated this outlier.

The second paper, by the same author, records the occurrence at Jebel Mzeita and Bordj Redir of strata similar in age and character to those above described. At the former locality, four bands of phosphate-rock occur in the marly limestones, but this rock is harder than at Jebel Dyr, black and speckled with white and grey (Coprolites). The thickest band is about $6\frac{1}{2}$ feet, and analysis has shown the phosphate percentage to average 66·5. The Bordj Redir outlier may be aptly compared with that of Ain Kissa, exactly as Ain Kissa has been let down by faults below the Jebel Dyr, so has Bordj Redir been let down below Jebel Mzeita.

There are here as many as eleven distinct bands of phosphate, one of which is 6½ to 10 feet thick. At Bel Imur are phosphatized shaly marls in the long 25 miles outcrop of Lower Eocene, but as one travels northward these phosphatized marls are seen to pass gradually into marly limestones. However, along a line drawn from Sukahras to Bordj-bu-Arreridj, 220 to 250 miles, there is a chain of these Suessonian outliers, all containing phosphates. These deposits, similarly to those occurring between Tebessa and Batna, are near the shore-line of the Suessonian sea, and their fossil contents, as well as their other characters, show that they were laid down in comparatively shallow water. O. S. E.

THE PHOSPHATE-DEPOSITS OF ALGERIA.

ANON. *The Colliery Engineer* (*Pennsylvania*), 1895, *vol. xv., page* 153.

Mr. Chas. T. Grellet, U.S. Consul at Algiers, reports to the State Department the working of important phosphate deposits in Algeria, which will, in the near future, seriously affect the European markets of American phosphates. Since 1886, the French explorers of Western Tunisia have mentioned the existence of large phosphate deposits in that country; and about two years ago similar discoveries were made in the department of Constantine (Eastern Algeria) in the region of Tebessa, about 155 miles south of Bone.

The mining of the phosphate is said to be exceeding easy and cheap, the Tebessa fertilizer being composed mostly of the bones and teeth of sharks, and being found in a semi-pulverulent state, in strata from 20 inches to 10 feet thick, intercalated in white marl and siliceous limestone.

Its strength varies from 60 to 70 per cent., and in some places reaches as high as 85 per cent. of tribasic phosphate of lime.

The phosphate-lands of Tebessa are now under the control of three firms, two of which are English, viz, Messrs. Crookstone Bros., who own Jebel Dyr, and the Constantine Phosphate Company, whose head office is at Leith, in Scotland.

The general output of these mines was about 5,000 tons in 1893; whilst this year (1895) it is expected to attain more than 30,000 tons. J. W.

THE PHOSPHATE-MINES OF CANADA.

By H. B. SMALL. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxi., pages* 774-782.

There are two main districts where apatite is mined: Quebec, the most important, and Ontario, which is not so extensively developed.

The rocks containing apatite are composed of pyroxene, quartzite, mica, gneiss, and crystalline limestone.

The apatite, or phosphate, as it is commonly called, occurs in a variety of forms, in crystals, or masses, in strata, and most commonly in a friable form known as "sugar-phosphate." When mixed with foreign substances it has to be cobbed by hand, which is rendered easy owing to the friable nature of the phosphate. The great drawback to this industry is the absence of sufficient quantities of pyrites in the neighbourhood for the manufacture there of sulphuric acid, which is used to convert the crude phosphate into a fertilizer.

The crude material is floated down the river Lievie, a tributary of the Ottawa, to Buckingham, where it is loaded into trucks and conveyed by rail to Montreal, whence it is shipped in great quantities to England and the European continent, very little of it finding its way to the United States.

That the industry is a growing one is shown by the increase in the exports from Canada, which in 1879 were 8,446 tons, and in 1889, 29,987 tons. A. W. G.

PHOSPHATE CHEMISTRY AS IT CONCERNS THE MINER.

By Thos. M. Chatard. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxi., pages* 160-175.

The writer describes the analysis of a natural phosphate, and urges the desirability of a standard method for analysing; pointing out the conflicting results arrived at by different chemists. A. W. G.

THE GEOLOGICAL ORIGIN OF PHOSPHATE OF LIME IN THE UNITED STATES AND CANADA.

By Walter B. M. Davidson. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxi., pages* 139-157.

The apatites of Canada occur as pockets in bands of pyroxene, overlying limestones of Laurentian age. The phosphoric acid was derived from the limestone which was subjected to great heat and pressure—causing folding—and the apatite crystallized out in pockets or cavities found along the lines of least resistance during the period of contortion.

Phosphate of lime has a curious faculty of motion and a great tendency to aggregation. The phosphate-beds of Carolina were deposited by a river flowing through a district of Vicksburg Limestone, whence the calcareous phosphate has been derived. The prevalence of fossils is due to the preserving action of the phosphate of lime, and the phosphoric acid in the beds was not derived from the bones, as was generally supposed, but most of that in the bones was derived from the beds.

The State of Florida is underlain by Eocene or Vicksburg Limestone with later Tertiary clays and sands. The limestone has been largely denuded, and it is from this that the various phosphate-beds derive their origin.

Nearly all deposits of phosphate of lime belong to the Cretaceous or later periods, and are either phosphatic limestones or chalks, or else a deposit of phosphate of lime lying on a limestone or chalk.

The same action of the various forms of life that secreted the carbonate which makes up the bulk of a limestone or chalk was at work extracting the phosphate from the waters of the ocean.

The writer was very much struck with the similarity of the West Indian and Florida phosphates and thinks that the origin of both is the same. A. W. G.

FLORIDA PEBBLE AND NODULAR PHOSPHATE OF LIME.

By Prof. E. T. Cox. *Engineering and Mining Journal* (*New York*), 1891, *vol. lii., pages* 359-360.

The author read a paper, at the Indianapolis meeting of the American Association for the Advancement of Science, on Florida hard rock-phosphate, when he applied the name of floridite to this mineral. The name was given chiefly on account of the physical differences that exist between it and other phosphates of lime, and the source of its origin. The author then explained that, in his opinion, the hard rock-floridite had been derived from the mineralization of ancient guano.

Along with the beds of hard rock-floridite are pockets of soft phosphate of lime, which latter has the appearance of a soft plastic clay, its colour varying from greyish-white to a kaolin-white. When dry, the soft phosphate yields from 75 to 84 per cent. of $Ca_3(PO_4)_2$. The beds of hard rock-phosphate follow the trend of the Gulf

of Mexico on the western side of the peninsula of Florida. They are of the Quaternary age and rest upon Eocene beds, sometimes attaining a vertical thickness of 60 feet or more, but generally much less.

The beds of floridite are not in a solid continuous stratum. They cover an area from Taylor and Madison counties, in the north, southward to Citrus county, forming a strip about 120 miles long by about 20 miles wide. The land- and river-pebble and nodular phosphate-belt commences south of Citrus county, and is traced as far south as Caloosahatchee river in Lee county. The pebble-phosphate occupies the same geological position as the floridite; it, too, follows the trend of the Gulf of Mexico, and is in non-continuous beds, which extend over an area of about 36 miles. The stratum of pebble-phosphate ranges from 3 to 30 feet in thickness, 12 feet being the average thickness in most parts. The pebbles contain from 70 to 80 per cent. of $Ca_3(PO_4)_2$, and their clay matrix contains about 50 per cent. of the same constituent.

In and near the town of Bartow, Polk county, there are found, resting on the pebble-bed, bones of the manatee and other animals.

The pebble-bed is remarkably free from fossils, but the author has found a few small sharks' teeth in it. The pebbles vary in size from that of a mustard seed to that of a hen's egg. Their colour varies from black to brown and milk-white. The phosphate of iron and alumina in the pebbles is rarely found above 3 per cent.

Dr. Henry Wurtz analysed a specimen of the nodular phosphates from Polk county, in the Peace river region, with the following results:—Tricalcium phosphate, 72·79 per cent.; aluminium phosphate, 3·28; ferrous phosphate, 3·08; calcium fluoride, 8·90; calcium carbonate, 0·41; calcium sulphate, 2·32; combined water, 2·64; organic (bitumenoid) matter, 0·44; quartz, 5·55; soluble silica, 0·12; total, 99·53 per cent. The specific gravity of the whole was 2·765, and of the compacter fragments 2·828. J. W.

PLATINUM IN CANADA.

Canadian Platinum. *By* J. T. Donald. *The Engineering and Mining Journal (New York), 1892, vol. liii., page 327.*

It has long been known that platinum had been found in this province. In the Report of the Geological Survey for 1851-52 it is stated that Dr. Hunt had detected native platinum in some of the gold-washings of the Chaudière district.

Canadian platinum-ore, as a commercial article, is entirely the product of British Columbia. In association with alluvial gold it has been met with in a number of the streams in that province.

At present, the most important platinum-bearing district of British Columbia, as well, indeed, as of North America, is that of the Tulameen or North Fork of the Similkameen river. A notable quantity of platinum has already been obtained from this district. One firm in the United States claims to have purchased within the last year or two fully 2,000 ounces of British Columbia platinum, and it is well known that a portion of the yield of this district has found its way to the London market.

An increased output may be expected, as the Tulameen Hydraulic and Improvement Company has made preparations to begin hydraulic mining on a large scale with the advent of spring. Two samples of the Tulameen ore contained 69·28 and 72 per cent. of platinum respectively. It is really a very complex alloy of platinum, with a number of the comparatively rare metals of this group, such as

palladium, iridium, and notably an alloy of osmium and iridium, known as osmiridium, which, in grains of proper size and form, is used for pen-points. This ore is worth to-day about 23s. (5½ dollars) per ounce troy.

The price is very unsteady, being determined by the demand for the metal and by the state of affairs in Russia, the principal producer of the ore. J. W.

A VARIABLE-SPEED PULLEY.

By H. C. Spaulding. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxi.*, *pages* 907-911.

The device consists of a narrow pulley with a deep V-groove, split by a plane passing through the bottom of the groove, one of the two symmetrical parts so formed being fixed to the shaft, and the second being capable of adjustment by means of screws and handwheels, so as to bring the faces of the groove nearer or farther apart. By the use of a narrow or round belt, and with faces having the proper angle, the working radius may be varied within wide limits, while a loose sheave may be inserted between the two parts, thus combining the differential-speed principle with the equivalent of a fast-and-loose pulley. A. W. G.

PUMPING-PLANT AT BOCKWA COLLIERY.

Die neue unterirdische Wasserhaltungs-Anlage in Bockwa bei Zwickau. By C. Schencke. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1893, *pages* 1-40, *with several drawings.*

This plant was designed to raise 3,300 gallons (15 cubic metres) of water per minute from a depth of 590 feet (180 metres).

The pumping-plant was designed in duplicate, each machine being capable of raising the average incoming water or 1,650 gallons (7·5 cubic metres) per minute.

The pumping-engines are placed in two chambers situated north and south of the shaft. The height of the engines is such that the water can accumulate for 6 to 8 hours in old levels before it rises to endanger the engines. There is also a connexion with a neighbouring mine below the level of the engine-rooms, and thus in case of emergency the water might be turned into the workings, so as to save the engines from being flooded.

The ventilation of the underground engine-rooms is secured by the end of the engine-room farthest from the shaft being connected with a special rise-staple and level leading into the upper part of the shaft. The air can consequently circulate, and an electrically-driven fan is placed in the shaft to facilitate the ventilation. The temperature in the height of summer has not exceeded 75 degs. Fahr., when the steam pressure was 90 lbs. per square inch.

The steam-pipes and boilers are designed to carry a pressure of 150 pounds per square inch (10 atmospheres). It was considered advisable to use high pressures, or at all events to be able to use high pressure in case of emergency. The steam-pipes, of which there are two, are made as small as possible, and the loss by condensation is found to be small. The pipes are of wrought-iron, with an inside diameter of 4 inches (100 millimetres). They are supported in the shaft at distances of 148 feet (45 metres), and at each support there is a copper expansion-pipe. This arrangement, for dealing with expansion, was not found to work satisfactorily, and it was found necessary to keep both steam-pipes filled with steam, in order to prevent leakages. The steam-pipes were tested by water to 300 lbs. per square inch, and the copper curved pipes to a steam-pressure of 120 lbs. The steam-pipes are guided in the shaft between two rollers. The pipes are jacketed with a preparation composed of cork, bound round with zinc wire, and

coated with gypsum, jute, and asphalte, and an outside sheathing of canvas, painted with Stockholm tar. The ends of the pipes are turned and bolted together with screw-bolts. The water-column consists of two cast-iron pipes 9¾ inches (250 millimetres) in diameter, and 29½ feet (9 metres) long. The pipes are supported in the shaft on iron girders and are guided between rollers. Expansion is provided for by means of bronze stuffing-boxes. The lower pipes were tested to 525 lbs. and the upper pipes to 300 lbs. per square inch. There are 4 Steinmuller boilers, each with 1,631 square feet (151·6 square metres) of heating surface. The boilers each contain 100 pipes, 3·7 inches in outside diameter and 16·5 feet in length, and one upper boiler 3·6 feet in diameter and 21·4 feet in length. The boilers are fed with a special fresh-water supply, the mine-water not being suitable. The engine-rooms, both at the surface and underground, are lighted by electric light.

Pumping Engines.—The engines were designed to pump the normal quantity of 660 gallons (3 cubic metres) per minute; and to be able in case of necessity to lift together 4,400 gallons (20 cubic metres) per minute. The engines are compound condensing: the high-pressure cylinder being 29·53 inches (750 millimetres), and the low-pressure cylinder, 43·31 inches (1,100 millimetres) in diameter, the length of stroke is 3·28 feet (1 metre); the average number of revolutions being 50, and the maximum 80 revolutions per minute.

The large plunger pump is 11·42 inches (290 millimetres), and the small plunger 7·87 inches (200 millimetres) in diameter, and the length of stroke, 3·28 feet (1 metre).

It was considered probable that in course of time the water would diminish, and that the pump would be required at the 1,287 feet level, consequently the parts of the engines were designed to resist the pressures at that depth, that is a pressure of 600 pounds per square inch (40 atmospheres).

The total cost of the installation amounted to £34,191 (683,832 marks), of which the two underground pumping engines cost £8,756.

The following results were obtained during the six months' run from January 1st to July 1st, 1893. Total water lifted, 146,660,800 gallons, or 562·5 gallons per minute, the costs for the same being as follows :—

	Expenditure.			Cost of lifting 1 cubic metre (220 gallons), 180 metres (590·4 feet).	Cost of lifting 1 cubic metre 1 metre high, metre-ton (7,216 foot-pounds).
	£	s.	d.	Pence.	Pence.
1,350 tons coal, including cartage	472	10	0	0·1704	0·000960
Wages and superintendence	614	9	8	0·2208	0·001200
Lubrication	133	3	9	0·0480	0·000240
Packing	20	0	0	0·0072	0·000036
Repairs	6	0	7	0·0024	0·000012
Insurances, taxes, etc.	47	4	7	0·0168	0·000096
Timber, iron, and general stores	30	2	10	0·0108	0·000060
Totals	£1,323	11	5	0·4764	0·002604

W. F. W.

THE IMPACT PUMP.

A Paradox in Hydraulics—The Impact Pump. *By* Gus. C. Henning. *American Machinist*, 1895, *vol. xviii., page* 5.

The impact pump consists of two parts: the piston, carrying an indiarubber valve, is driven by a connecting-rod through a stuffing-box in the usual way; the valve works in an enlargement of the suction-pipe, and the piston works in a cylindrical chamber below the enlargement. The rising-main is attached at one side of the valve-chamber.

The following table records experiments made upon an impact pump, whose piston was 3·156 inches in diameter, with stroke of 2·362 inches, and a displacement for one stroke of 18·46 cubic inches:—

Revolutions of Crank.	Work Transmitted. Q.	Orifice of Discharge above Water-level.	Actual Delivery.	Actual Work Done. Q^1.	Efficiency. $\frac{Q^1}{Q}$.	Theoretical Piston Displacement.
	Foot-pounds.	Feet.	Gallons.	Foot-pounds.	Per Cent.	Gallons.
295	27,510	49·85	46·70	20,950	76·1	23·5
302	29,047	49·85	54·78	22,820	78·5	24·1
349	32,547	49·85	55·25	25,324	77·8	27·9
352	30,810	49·85	62·38	25,985	84·3	28·1
360	31,590	49·85	63·32	26,380	83·5	28·8
417	37,536	49·85	75·19	31,325	83·5	33·3
278	41,442	101·7	46·07	39,146	94·5	22·2
289	44,828	101·7	47·34	40,225	89·7	23·1
299	46,434	101·7	51·45	43,721	94·1	23·9
308	48,170	101·7	53·02	45,068	93·5	24·6
319	47,953	101·7	51·30	43,577	90·9	25·5
321	48,388	101·7	53·02	45,068	93·1	25·6

The table shows that the capacity of the impact pump is more than double that due to the piston-displacement, whilst the efficiency rises from 76 per cent. with the low lift to 94 per cent. under the conditions of the high lift.

M. W. B.

PULSOMETER PUMPS.

Neuerungen an Pulsometern. ANON. *Dingler's Polytechnisches Journal*, 1893, *vol.* 290, *page* 1.

Amongst the advantages of the pulsometer pump may be counted its simplicity both of construction and working, the small amount of repair required, and the ease with which it may be fixed in inconvenient positions. The following are the results given of an experiment with a Körting No. 8 pulsometer pump on the Royal Hanoverian railway. The pulsometer was erected in the stream 65·6 feet (20 metres) from the boiler, and 22 feet (6·75 metres) above the level of the water; the water was raised to a level of 80½ feet (24·5 metres) above the pulsometer pump, so that the total height was 102·5 feet (31·25 metres):—

Duration of experiment ...	79 minutes.		
Quantity of water raised ...	144·46 cubic metres	...	31794·2 gallons
Water used in boiler	900 litres	...	198·0 ,,
Coal used	109 kilogrammes	...	240·3 lbs.
Temperature of stream ...	9·8 degs. Cent.	...	49·64 degs. Fahr.
Temperature of water in delivery-pipe	13·4 ,,	...	56·12 ,,
Number of pulsations per minute	57.		
Pressure of steam in boiler ...	7 atmospheres	...	103 lbs. per square inch.
,, ,, pulsometer	6·5 ,,	...	95·5 ,, ,,

Thus 402·16 gallons (1,828 litres) were lifted 102·5 feet (31·25 metres) per minute.

W. M.

THE CARE OF WIRE ROPES.

By J. H. Janeway, Jun. *The Colliery Engineer (Pennsylvania)*, 1895, *vol. xv., page* 148.

The author points out the economy of effective lubrication and recommends a first-class lubricant, which, he says, anyone can make, of tar, summer oil and mica axle-grease, in varying proportions to suit the conditions. The tar and oil must be free from acid. The combination is said to thoroughly penetrate between the wires to prevent rust, and fills the cable so as to give it the appearence of a bar of iron. It resists water successfully and does not strip off. Old wire-ropes which have been treated with this material, when taken apart, show every wire bright and clean, the heart or hemp core being in prime condition. As soon as a wire rope has been well filled with this compound, the addition of a very little, from time to time, is said to keep the rope in good condition, so that the lubricant is economical. It is stated that it costs in some cases only one-eighth as much per year as the old materials, with far better results; and, further, a well lubricated rope lasts from 25 to 50 per cent. longer time. J. W.

IMPROVEMENTS IN QUARRYING MACHINERY.

Anon. *The Engineering and Mining Journal (New York)*, 1895, *vol. lix., pages* 416-417, *and* 2 *illustrations.*

Two forms of channelling-machine, manufactured by the Ingersoll-Sergeant Drill Company, operated by compressed air or steam, are described and illustrated. The first drawing shows the improved stone channelling-machine doing corner and angle work in a quarry; the second shows the undercutting track-channeller for horizontal channelling.

The following figures, given by Mr. F. C. Neeb, a quarry operator in Ohio, show comparative results between hand, steam, and compressed-air drilling and reaming:—

By Hand.—Cost of drilling and reaming, September, 1891, 4,447 feet of top hole and 1,791 feet of side hole; total number of feet drilled, 6,238; cost 535·16 dollars; cost per foot 4·3d. (8·6 cents).

With Steam.—Cost of drilling and reaming, September, 1892, 5,629 feet of top hole and 1,874 feet of side hole; total number of feet drilled, 7,503; cost 438 dollars; cost per foot 3·25d. (6·5 cents).

With Compressed Air.—Cost of drilling and reaming, September, 1893, 8,007 feet of top hole and 2,394 feet of side hole; total number of feet drilled, 10,401; cost 449·50 dollars; cost per foot 2·15d. (4·3 cents).

These results include the cost of all blacksmith work, fuel, oil, etc. J. W.

A MINE RESPIRATOR.

Schutzvorrichtung gegen das Einatmen schädlicher Gase, insbesondere zum Schutz gegen Nachschwaden. Anon. *Glückauf*, 1894, *pages* 577-78.

This apparatus is intended to preserve miners from the effects of after-damp. It can only be used at mines in which compressed-air machinery is used, and consists of a long canvas sack, open at one end and closed at the other, which is connected by pipes with a compressed-air pipe. This sack is provided with a number of openings, fastened by strings. In case of need, the workman turns the tap which connects the sack with the compressed-air pipe, puts his head through one of the openings into the sack, tying it close round his neck with the strings, so that he can breathe pure air while the rest of his body is in the vitiated atmosphere of the mine. J. H. M.

WORKING OF SALT-MINES IN AUSTRIA.

Abschluss des Schachtwerkbetriebes am Ausseer Salzberg. By A. Schernthanner. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli., page* 543

The author describes the results obtained by working the salt mountains in the Aussee district in Upper Austria according to his system. These mountains contain large salt-deposits, but the Salzberg is the richest of all. Owing, however, to previous defects in the working methods, the production had greatly diminished. Formerly the salt in this mountain was obtained by solution in horizontal layers by the action of water. An artificial lake was thus formed, flooded with water, and after due time allowed for impregnation, the brine was drawn off. The disadvantage of this system was that the water had an unavoidable tendency to spread; the workings thus became enlarged horizontally, and not only was the mountain undermined, but the brine continually diminished in strength. The different beds were broken through, and began to run one into the other, and the working results were negative. An attempt was made to remedy the evil by working two seams simultaneously one above the other, but to support them it was necessary to leave so great a thickness of rock that the loss was about 32 per cent. Owing to these reasons it was seen that the system of working the salt-mines was radically defective, and must be wholly remodelled, unless these rich salt-works were to be abandoned.

The faults of the method were, in the author's opinion, twofold. Firstly, the salt was worked from a horizontal area, whereas, if it were possible to work it vertically, the water would have the sides and roof of the excavation to play upon, as well as the bottom. Another disadvantage of this arrangement was that the residuum was gradually deposited on the bottom of the bed and prevented the free action of the water on the rock-salt. Each time the bed was flooded the water could not penetrate the *débris* and reach the rock-salt below. The net result was that the strength of the brine brought to the surface only corresponded to a proportion of 48 per cent. of salt. The second objection to the old system was that the water-flow could not be regulated. The water was first admitted at the bottom of the seam, and it was assumed that it would rise, gradually dissolving the salt above it, till the working attained a considerable height. Instead of this the water spread laterally. In one working, for instance, it was found that after the water had risen to a height of $13\frac{1}{2}$ feet no more brine could be obtained.

The new method adopted was similar to that in use at the salt-works at Middlesborough. After sinking a small vertical shaft, an iron pipe was passed down it, and the flow commenced from the top, instead of the bottom of a salt-bed, the water being injected against the rock sides of the shaft. At its lower end the pipe terminated in a small jet. The water was first allowed to play upon the rock round the bottom of the shaft, and could be directed against it either horizontally or at an angle. As the space became filled with saturated brine, the action of the jet diminished, until a complete seam was excavated, which was then filled with water, and after a time the brine drawn off. The quantity of salt thus obtained was measured, and from it the size of the excavation calculated. As soon as, by drawing off the brine, the space had been enlarged to the dimensions previously determined, the injection of water was stopped. A calculated vertical thickness of rock above the seam was left as a support, and above it the jet was again introduced, and the process repeated. Thus a succession of spaces were formed one above the other, the dimensions of which were determined with mathematical precision from the volume of brine brought up. The lowest space was preserved intact by leaving it full of strong brine, and care was taken never to allow any of the seams to extend beyond the

bed of the original lowest working; their dimensions were easily regulated by the new method. To show to what extent the introduction of the water could be controlled, the excavations were sometimes carried right up to the top of the shaft.

One of the main advantages of the new system was that it permitted disused beds, which had been abandoned as unsafe, to be again worked. In many of them it had been found necessary to support the roof, but by the simple process of sinking a shaft over the roof, the props were rendered superfluous. By injecting water and drawing off the brine, the pressure of the roof was gradually removed, all danger of falling in was avoided, and the part of the mine above the old seam was made productive. The results of the new system were as satisfactory as the author had anticipated.

He divides the subject under three heads, and considers (1) theoretical results; (2) practical results under the old system; and (3) practical results under the new. Theoretically, with two beds worked after the old style, one above the other, to allow a depth of excavation of 42½ feet for the upper bed, it was necessary to leave a thickness of 16½ feet below and 19½ feet above, to support it. Practically, taking the beds yielding the most brine, when excavated to a depth of 121½ feet, the water only saturated the brine to a depth of 75½ feet, and the remaining 46 feet were lost. With the new system, saturation and excavation proceeded together. During a period of nearly 6½ years, the height of the column of dissolving liquid was 98 feet, and the quantity of brine produced 466,340 cubic feet per 24 hours. Comparing the two, about 86 cubic feet of brine were raised per hour with the old, and 188 cubic feet per hour with the new method, or more than double. The author attributes this striking result to the fact that the brine being drawn off from the bottom of the bed, while saturation takes place from the top, it is always carried off at a high pressure; and from the same cause the last quantity of brine is richest, and contains the largest proportion of salt. With a roof area of 32,280 square feet, about 10,590,000 cubic feet of brine are obtained. As this area may be doubled without risk of the roof falling in, the production of brine can be correspondingly increased.

The usual form given to the spaces is reversed in the new system. Instead of making the bottom broad and the roof contracted, to diminish the weight of the vault upon the sides, the roof is wide and vaulted. The walls are concave, narrowing to the bottom, which is often comparatively very small, but large enough to afford space for the accumulation of the *débris* and waste. B. D.

ALPINE SALT-WORKS, AUSTRIA.

Ueber die Ursachen der Todtsprechung Alpiner Laugwerke. *By* C. Schraml *and* August Aigner. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli., pages* 555-559, 569-573, and 625-627.

It is a fact well known to salt-mining engineers that many salt-works, and those which appear most promising, fail suddenly, and often give way just when the heavy outlay on the plant, etc., is beginning to bear fruit. The attempt has often been made to examine more closely the causes of this phenomenon, and to explain them on theoretical grounds. The result showed that the existing methods of working in almost all Alpine salt-mines were very defective, chiefly because the saturation of the brine affected the stability of the surrounding rock. To obtain a clear view of the circumstances which caused the abandonment of many workings in the salt-mine at Hallstadt, Mr. Schraml has classified them in a tabular form, and this he was enabled to do with the greatest ease, because

for more than a hundred years the history of this mine has been carefully kept. It contains in all 124 workings, from the Catherina Theresia gallery downwards, which have at various times been abandoned, either because the brine was exhausted, or for other reasons.

There are four galleries or levels in this mine. The highest, the Catherina Theresia level, and the next the Leopold level, have been almost wholly worked out. The largest quantity of brine is at present obtained from the Joseph level, while the deepest of all, the Kaiserin Christina level, has hitherto been little excavated. In the Catherina Theresia level 64 workings have been abandoned; in the Leopold level 42; in the Joseph level 14; and in the Christina level 4. The mine was opened in 1681, and the first workings date from that period. The time during which brine has been extracted from these levels varies from four years (1819-1823, when the outlet from this working became unserviceable) to 172 years (1717 to 1889); in the latter case the workings fell in entirely. A startling fact is that out of 124 abandoned workings only 32, or one quarter, were exhausted, while in the remaining three-fourths other causes were at work to bring operations to an untimely end.

The causes of the failure of the different workings have been carefully analysed, and for this purpose Mr. Schraml has divided them into ten separate groups.

The first comprises those workings which have been abandoned because the brine was exhausted; the remaining nine fall under two heads, viz., three in which, according to the author, the causes of failure were avoidable, and six where they were unavoidable.

The second group include nine workings which have fallen in because the roof-area was too large, and several workings ran one into the other. Of these only four had a roof-area of more than 60,000 square feet, which used to be considered the bearing strength of a roof. In more than half, this limit was not reached. On the other hand, there are levels still worked where the roof-area of 97,000 square feet and more has remained intact for years; it seems therefore impossible to determine the limit of safety. In the case of four of these workings, where the roof-area was very small, their fall might have been avoided had the limits of resistance been rightly understood.

The third group comprises five workings abandoned through errors of construction.

The fourth group comprises ten small workings from which only a small quantity of saturated brine had been withdrawn when mining operations were stopped, and the floor and the rock turned to better account.

Thus far, workings abandoned intentionally, or from natural or avoidable causes, have been considered. The fifth group comprises those which have broken into the workings below, owing to fissures or porosity in the rock. One-fourth of the whole number belong to this class, and hence it is the most important of all. Is it, or is it not, possible to prevent workings in salt-mines from breaking down in this way? It must be remembered that brine is never so thoroughly saturated that an increase in its specific weight is impossible. Fissures in the rocks have been discovered containing brine which yielded 3·7 lbs. of salt per gallon. That brine can be so strong is owing to its capacity of taking up extraneous salts. In this way one may account for the otherwise inexplicable phenomenon that concentrated brine in the heart of the mountain eats away hollow vertical tubular spaces, often many feet in length. Thus one need not attribute the fall of the workings to actual fissures in the rock, which might seriously affect the present system of mining. There are numerous courses of anhydrite and other minerals impregnated with salts, which drain off the brine in one direction, and make it impossible to

raise it to the surface in another. Recently seven workings were rapidly abandoned one after the other, because the rock was porous and allowed the brine to filter away. Each of these had been formed on the Schwind system, one above the other, strong intermediate rock, 65 feet thick, divided the bottom of the level from the discharge-outlet, and some areas had already been worked successfully for years before the side walls reached the strata of porous rock.

In the sixth group the workings were abandoned because of the fall of the rock-roof. It is impossible always to fix the limits to which the salt extends. Often workings are opened containing abundance of salt, close to the periphery of the mine, and in the process of saturation and consequent extension of the space, the confines of the outer rock are reached. According to the character and stratification of the latter, it is either possible to continue working, the walls at the limit of the salt remaining vertical and intact, or if the roof of the spaces overhangs, the walls give way, the rock falls in, and the working must be abandoned. From the latter cause, no fewer than 16 workings have been closed. If to avoid this mischief, a broad zone were left untouched round the salt-deposit, the extent of which can often be only surmised, the number of workings in a mine would be greatly diminished, and the salt could no longer be produced at a profit.

The seventh group comprises workings abandoned through danger of cutting into other strata, levels, or shafts, and especially those in which the old method of solution had unduly widened the walls and rendered the dams or barriers useless. The new working-system of large iron pipes to admit the water, rapidly saturating the brine, and supplying water by a shaft or from above, will prevent this mischief in the future, especially if the dividing-barriers or dams be of sufficient strength. As these workings were abandoned because of erroneous methods of irrigation, their failure may be classed among avoidable errors.

The eighth and ninth groups consist of small workings abandoned either because during saturation beds of unproductive rock were encountered, or because the mineral became much poorer in salt.

In the tenth group are classed those workings where the rock above the salt strata fell in. Although sunk vertically one below the other, in accordance with mining rules, these workings had to be prematurely closed, probably because the roof was no longer able to bear the weight of the rock above it. In one of them, the supporting rock was 26 feet, in the others 36 feet thick or more, and thus according to received rules there should have been no danger of a fall. But new workings (also since abandoned) had been opened, the floor of the older levels watered, and thus their fall as it were actually prepared. The unequal supporting power of the roof was here most strikingly shown. While in many of these later underpinned workings the brine could be saturated without difficulty almost up to the working next above it, in others the intermediate rock fell in when brine to a depth of only 19 feet had been extracted, although the level above it was often not more than 32 feet in diameter. The heterogeneous structure of the rocks in this part of the mountain made it absolutely impossible to determine the bearing strength of the roof.

The following is a classification of the different groups of abandoned workings, according to their cause of failure:—32 workings, or 28 per cent., were worked out and exhausted naturally; 19 workings, or 17 per cent., were abandoned prematurely from avoidable, and 62, or 55 per cent., from unavoidable, causes; 11 workings fall under none of these divisions. In the workings prematurely abandoned, 77 per cent. were owing to the quality of the rock, and 23 per cent. to defective working methods. These figures may help to re-establish the reputation of the Alpine salt-mines, and explain their comparatively small yield of brine.

Hitherto, this has been attributed entirely to want of skill of the mining engineer, and the varying geological and physical conformation of the rock has not been taken into account. It is impossible to avoid the use of water to dissolve the salt, except by some dry process of working the mines, which would be far more costly. In spite of the better methods now employed to saturate the brine and support the galleries, Mr. Schraml fears that no considerable diminution in the number of abandoned workings is to be looked for.

From the same statistical information, Mr. Schraml also gives the number of years during which the workings in the different galleries are utilized, and the quantity of brine saturated. Of the four galleries in the Hallstadt salt-mine, the first two, containing respectively 61 and 45 workings, are almost exhausted. The average length of time for each working is 56 years in one, 82 years in the other, and the average depth of saturated brine in both galleries is 44 feet per working. The other two galleries are still being developed; there are 14 workings in the one, and 4 in the other, which have been utilized 47 and 50 years respectively. The depth of saturated brine is 23 feet. The average time during which a working is productive appears to be in proportion to the height of the roof, but the latter is independent of the quantity of brine obtained. The mean area of the roof in the 32 workings which were exhausted naturally was about 32,000 square feet.

The view taken by Mr. Schraml that the abandonment of the Hallstadt salt-workings is due, not to defects in the method of working, but chiefly to unavoidable causes, is contested by Mr. August Aigner. As early as 1849, Mr. Schwind laid down the important principle that between two workings in a mine there must always be a carrying wall, and it is owing to this condition that the Ischl salt-mines have been so successfully worked. Sixty years ago it was the general opinion that a yield of only 3 per cent. could be obtained from salt-mines. Mr. Schwind, who may be considered as the founder of modern scientific salt-mine engineering, set himself steadfastly against this view. To refute it, nothing, he declared, was necessary, but to adopt his own principles of working mines, which are now universally accepted.

Briefly stated, these were that the workings should be set one above the other, in tiers, like the stories of a house; and in spite of the expense involved, he considered it necessary to have a network of supporting walls from top to bottom of the vertical galleries. Had this condition been observed in salt-mining 50 years ago, the falling in of numberless workings would have been avoided. To prove, however, that even now it is not strictly adhered to, it is only necessary to examine the list given by Mr. Schraml of workings prematurely abandoned. Mr. Aigner has drawn up a chart representing a few of these in section, which shows at once that the excavations did not rest upon solid rock. The loss in working may be estimated by the fact that out of 124 workings, with a total height of 4,900 feet, to which the brine might have been saturated, it was dissolved only to a height of 1,920 feet, or only 40 per cent. A glance at the plan of the workings, with its irregular masses of intermediate rock, and the projections in every direction of the salt-bearing strata, always produced during the slow process of saturation, justifies the opinion that very little salt has been extracted, in comparison with what remains.

Mr. Aigner then proceeds to apply Mr. Schwind's principle to the Hallstadt mine. Here the galleries, being ranged one above the other, like the stories of a house, it would be vain to attempt to introduce a middle wall into this labyrinth of spaces. The whole of the mining region excavated is pierced with shafts for conducting water, which for hundreds of years has been at the same pressure in the shafts and galleries. The weight of all the workings has been estimated at

238,500,000 tons, and over them is a roof continually in motion, sometimes shaken by earthquakes, and resting upon no props, such as would be required in any building of the same extent. No wonder that the constant shifting and pressure of the loose mass of saliferous clay gives rise to all kinds of fissures, and that workings with a roof-area of only 5,400 square feet have to be abandoned, while others in a better situation can be worked in safety with an area of nearly 100,000 square feet.

It is true that we do not know all the influences which cause workings to give way, but by studying a few of those described by Mr. Schraml we may arrive at some understanding of the subject. Two of these fell in because another working was run below and between them, two others because they had been allowed to extend too far, and a fifth had to be abandoned because the neighbouring workings were unsafe. Another working gave way because it was situated above two others, one of which fell into a third, and the condition of the second was precarious. It is impossible to trace the causes of all the accidents in the 10 groups into which Mr. Schraml has divided the working of the Hallstadt salt-mine, but the foregoing are sufficient to show the futility of basing modern mining operations upon antiquated principles.

Mr. Schraml says, of 124 workings only 32, or one-fourth, have been naturally exhausted, and Mr. Aigner observes that this small useful percentage was obtained when, according to received opinion, the height of the galleries was only 92 feet, whereas on the modern shaft system they can be made 124 feet high. In the second group, 9 workings fell through owing to too great extension of the roof-area. One of these had an area of nearly 97,000 square feet; in the Aussee salt-mine there are workings which did not give way till an area had been attained of 146,000 square feet. The carrying power of the rock in a salt-mine is therefore enormous, and if these small workings had been surrounded with strong and indissoluble walls of solid rock, much better results might have been obtained. For every salt deposit there is a maximum roof-area that it can safely support, and the limits of which we can determine. The failure of this group must therefore be ascribed to the ignorance of the laws of stability prevailing in the last century.

Faults of construction and saturation of the floor are responsible for loss in the next 16 workings. Several of these would not have fallen in had they stood isolated. Thirty-one workings gave way owing to fissured or porous rock in the workings below them. This is attributed by Mr. Schraml to the fact that the brine, already saturated to the extent of 3·7 lbs. per gallon, became still heavier and ate its way down, by absorbing other salts; but few mining engineers will admit that this can happen. It would then be impossible to work salt-mines at all. In the Ischl and Aussee mines, which are as rich as those at Hallstadt in sulphates of soda, potassium, and magnesia, no case is known of one working running into another in this way. These solutions are more rapidly formed in fissures produced by general disturbance of the deposit, and hence by dividing the workings more regularly they may be avoided. The same may be said of cases where the workings were abandoned through the fall of the rock roof. In the Ischl mine, nearly all the workings towards the south have a sloping roof, and in only one has it given way.

In short, of the workings here examined all, except those which were naturally exhausted, failed because they were not properly supported. The method of saturating and drawing-off of the brine has already been brought to great perfection; but this will be of no practical use unless the working itself which yields the brine is maintained intact by a barrier of solid rock around it. B. D.

THE BRIXLEGG MINES, TYROL, AUSTRIA.

Der Bergbau Brixlegg im Tyrol. Anon. *Glückauf*, 1893, *page* 1437.

The Brixlegg mines belonged in the Middle Ages to the most celebrated mines in Europe, but now the industry is of only small importance. The lodes average 3 feet in thickness and contain principally silver-ore. The old workings were drained by the Bertha adit, but since 1881 a new adit some 200 feet deeper has been driven, and promises to be of great importance to the district. It has already attained a length of 3,000 feet.

The mineral output of the district will average annually :—

	Tons.
Ore for crushing, washing, and stamping	5,560
Copper and silver-ores saleable to smelting works	999
Iron-ores	1,006
Barytes	538

The barytes is ground fine : the annual sale of ground material being about 80 tons. The ore-concentration works are only worked in summer. W. F. W.

THE HIENDELAENCINA SILVER DISTRICT, SPAIN.

Hiendelaencina. Anon. *Revista Minera*, 1894, *vol. xlv., pages* 34-36.

The famous Hiendelaencina silver-mining district, which dates from the year 1844, is situated 65 miles from Madrid, 13½ miles from the station of Jadraque, on the Zaragoza railway, and at an elevation of 3,540 feet above sea-level. The deposits are concretionary lodes in gneiss, with a gangue of barytes, fluor-spar, and quartz, and bearing spathic iron, pyrites, and chalcopyrite. They continue perfectly characterized to the lowest depth yet reached (1,805 feet).

They are classed into three systems, one running east and west, with a northerly dip ; one north and south, with an easterly and westerly dip ; and a third with intermediate strike. Of these the first appears to be the principal ; it includes 3 parallel lodes, of which that known as the *filon rico* was the most productive in the early history of the district. Particulars are given of the mines now working on this and other lodes.

All the ore at present raised is treated by amalgamation at the Constante works, nearly 4 miles north of Hiendelaencina.

According to a paper written in 1875 by Mr. D. Miguel Bautista, the district produced up to 1870 a weight of 10,467,631 ounces of silver. G. E. C.

THE SILVER ORES AND OTHER MINERALS OF MILOS.

Les Minerais d'Argent de Milo. By L. de Launay. *Annales des Mines*, 1894. *series* 9, *vol. vi., pages* 345-353, *with map and section in the text.*

The general geological features of the island are as follows :—On the eastern coast are crystalline schists, overlain by trachytes, which are worked at Revma for grindstones and at Firlingos for sulphur. These in their turn are capped by tuffs, conglomerates, and highly fossiliferous Pliocene limestones. Along the southern coast range Jurassic and Neocomian limestones, dipping north, and rising in places to 1,600 feet above sea-level. Tertiary eruptive rocks, pyroxene sanidine-trachytes, form the chief mountain-summits of the island, and these are unconformably overlain by the liparite or quartziferous oligoclase-trachyte, which is essentially the metalliferous rock of the island.

The silver ores occur mainly as sulphides in association with barium sulphate in clay-pockets in the liparite; this clay appears to be a product of the surface-decomposition of the rock. Traces of silver chloride are present. Some of the masses of grey or black argentiferous clay are as much as 38 feet across. Generally speaking, the ores are poor, and where rich the percentage of silver is extremely variable. At Triades, the silver sulphide is disseminated in the clay in so fine a state of division that it cannot be differentiated by the naked eye. The workings have not been pushed very far; they consist of five small galleries and five shafts (the deepest of the latter being 72 feet). Twenty thousand tons of mineral were got out here between 1884 and 1890. At Cape Vani, the argentiferous deposits are closely associated with manganese ores, reminding the observer of a similar association in Montana and Colorada. Other silver-ore deposits have been discovered at Mount Mirovilia and at Pilonisi. The total mass of argentiferous rock in Milos has been estimated at 10,000,000 tons, with a mean content of 17½ ounces of silver per ton. The author quotes analyses by Mr. Cordella, and from the calculations made it would appear that ores of a grade lower than 21 ounces per ton cannot be exported with any advantage to foreign smelting-works. They must be treated on the spot in the wet way (chloridizing-roasting, lixiviation, and precipitation by copper) or at Laurium. The Hellenic Government have now taken in hand the working of the ores as a State enterprise.

Turning to the other minerals of economic interest, manganese occurs at several localities in the island, but the only important workings are those of Chalaka, Cape Vani (Miocene age), belonging to a French company. The number of workpeople is from 200 to 300, the wages being for miners 2s. to 2s. 9d. per day, for others 9½d. to 1s. 5d. per day. The annual production averages 18,000 tons, most of which is exported to Great Britain, France, and America.

Abundant sulphur-deposits, arising from solfatares, occur in pockets in the trachytes; the 2,000 tons yearly extracted are used chiefly in Greece itself for viticultural purposes. The State works a gypsum-deposit at Mount Damianos. Alum occurs abundantly, but so far has not been worked. A few brine-springs are known, and the salt from them is evaporated (260 tons per annum).

The grindstones of Milos have been in repute in the Levant for many centuries, and the quarries now worked near Revma belong to the State; the grindstone is a very compact yet porous silicified trachyte. O. S. E.

THE SILVER-LEAD ORES OF KARATSHAI, CAUCASUS.

Das Erzgebiet von Karatschai im nördlichen Kaukasus. By A. D. Kondratieff. *Zeitschrift für praktische Geologie*, 1894, *pages* 369-380, *and plate VI., with figures in the text.*

The district of Karatshai covers an area of about 1,225 square miles in the northern Caucasus; it has only been opened up in recent years by the construction of a high road, and the mining rights were leased in April, 1894, for 90 years to the Elborus Company of St. Petersburg. Going southward up the Kuban valley towards the mountains, one passes successively over Tertiary marls and soft sandstone, Cretaceous, and Jurassic rocks, all dipping gently north-eastward and striking generally parallel with the Caucasus range. But the dip is seen to become much steeper as one approaches the mountains, and, near the old fortress of Chumara, greenstones (doubtless porphyrites) are met with, which account for the great disturbance of the stratified rocks: they are in part contemporaneous with the Jurassic. From this point onwards crystalline rocks predominate,

bearing only here and there patches of sedimentaries, and even these disappear altogether some 20 miles before one ascends to the peaks of Elburz. The core of the range is made up of several varieties of granitic rocks.

The Cretaceous strata offer little of interest to the miner, excepting the possible occurrence of rock-salt in the Neocomian. In the Jurassic are extensive lignite-deposits, mostly interbedded with sandstones ; the thickness of the seams ranges from 1·8 to 6·5 feet, and at some localities the coal yields a very fair coke. Good fireclay occurs some 6 miles away from the silver-lead mines, and has been advantageously used for muffles and bricks.

The country-rock of the ore deposits is chiefly felsitic porphyry, curiously associated with talc-, mica-, and chlorite-schists of pre-Jurassic age. In this area of crystalline rocks also occur graphite-slates and iron-mica-schists with manganese ores.

Post-Jurassic movements of elevation of the earth's crust in Karatshai doubtless account for the system of fissures which now form the metalliferous lodes of that mining field. The author divides these into five groups, which are not only geographically distinct, but correspond with a particular facies, texture, and ore-combination of the lodes. These groups are :—

1. The *Indish Group*, the northernmost of any. Here three deposits are known, one of which (lower vein) is a combination of copper and lead ores, with 1·53 per cent. of metallic silver ; the second (upper vein) is a combination of galena and iron pyrites, and the third consists exclusively of arsenical pyrites, an ore unknown elsewhere in the Karatshai district. A trial working showed that the gangue of the upper vein consists of ochre, calcspar, and fragments of the quartzitic country-rock.

2. The *Djalankol Group*, $3\frac{3}{4}$ miles south-east of the preceding one, comprises, so far as known, four lodes which are distinguished by their brecciated character ; by the coarsely granular habit of the ore ; and by the occurrence of heavy spar (here the chief gangue-material), from all other lodes in Karatshai. Three of the lodes attain a thickness of more than 6 feet.

3. The *Daut Group*, up the valley of that name, a tributary of the Kuban. Here seven lodes are known, one of which is notable for its large proportion of silver (0·257 for every 100 parts of lead). At the outcrop of these lodes weathering and atmospheric leaching have at many points destroyed all traces of ore, but on striking a few feet deeper down one generally meets with a thick metalliferous lode. The uppermost lode continues into a patch of Jurassic shales overlying the crystalline rocks, and thus gives a time-standard as to the epoch when the lodes of the district were formed.

4. The *Kuban-Chudess Group*. The map which accompanies the original paper shows that this is included in the triangular area defined by the course of the Kuban river and its affluent the Chudess. It is the best known and the most important of any group in Karatshai. The lodes are $3\frac{1}{4}$ to 5 feet thick, with smooth curved side-walls ; the ores are galena and zinc-blende, with rarely a sprinkling of iron and copper pyrites, forming continuous seams in the lode. A disposition on the part of the galena to form a salband by accumulation at the sides is very noticeable. The gangue is made up of fragments of country-rock, and at some points the lode becomes a true breccia. More than forty separate ore-deposits are known in this group, and the author describes the most actively worked of these in detail. The saying of the German miners that a friable 'country' makes a poor lode is, on the whole, confirmed here. There are some exceptions, but the veins in the talc-schists are inferior in compactness and thickness to those

in the felsite-porphyry. The most important exception is the Chudess lode, which cuts obliquely through the eastern [? western] slope of that valley ; it is about 9½ feet thick, and the country-rock is mica-schist. The absence of zinc-blende and other impurities heightens the value of this lode, as also the high silver content (0·17 in 100 parts of lead) ; in olden times it was worked by firing the rock.

5. The *Utsh-Kulan Group* comprises so far two lodes in granite-porphyry, one of which is highly argentiferous. This outcrop, high up on the hillside, allows of easy working by adits, and that is an observation which applies to lodes in the other groups.

The paper concludes with an elaborate table of all the known lodes in Karatshai, giving their exact localities, strike and dip, and mineralogical and chemical composition. O. S. E.

COLQUECHACA SILVER-MINES, BOLIVIA.

The Silver-Mines of Colquechaca, Bolivia. By Robert Peele, Jun. *Engineering and Mining Journal* (*New York*), 1894, *vol. lvii., pages* 78-79, 100-101.

Colquechaca, a mining town of some 7,000 population, is situate in Central Bolivia, in the eastern range of the Andes, at an elevation of 14,000 feet. It is about 90 miles by rough road, just constructed, from the narrow-gauge railroad which enters Bolivia from the Chilian port of Antofagasta.

Mining in the district dates back at least two centuries, but there are no records of production previous to 1865. Since then 21,000,000 dollars worth of silver has been extracted from the San Bartolomé tunnel alone, while 5,700,000 dollars has been raised since 1884 from the upper tunnel. From May 1st, 1892, to March 1st, 1893, the production was 809,000 ounces, which will be largely increased when the machinery now ordered is erected.

The deposits are fissure-veins in dacite and rhyolite, the most important being that known as the Embudo, which is traceable for over two miles. It dips into the mountain at from 75 degs. to nearly vertical. The ore-distribution is pockety and extremely irregular, but varies generally from 2 to 12 inches in thickness. The vein is clearly defined, with slickensides and clay gouge, and often contains cavities lined with crystals of pyrargyrite and quartz with wire silver. The rich ore consists mainly of ruby silver, native silver, and argentite, associated with sphalerite and a little galena ; most of the value being in ruby silver. It runs from 500 to 5,000 ounces, second-class ore varying from 100 to 200 ounces per ton.

The other lodes of the group lie on one side of, and within 400 feet of, the Embudo. They are similar in character and hold good in depth, but their lateral extension is small.

The hoisting and pumping arrangements are bad and inefficient, at one mine only 20 per cent. of the underground hands being engaged on productive work ; but this will be modified consequent on a consolidation in May, 1892, by which all the mines are placed under one management. The San Bartolomé tunnel has now been straightened throughout its length of 5,035 feet to permit of the use of locomotives.

The high-grade ore is picked, hand-jigged, and exported to Europe. The ores under 300 ounces per ton are treated at primitive amalgamation-works near Colquechaca, where the loss in tailings averages 30 per cent. of the assay value. The charge for treatment was formerly about 60 dollars per 2,000 lbs., the actual costs being somewhat as follows :—

	Dollars.
Crushing	2·25
Roasting	7·25
Barrel amalgamation	9·55
Retorting, superintendence, etc.	6·50
Total	25·55

Amalgamation in *fondos* (copper-pots, set on rude furnaces) cost about 10 dollars per ton more.

One of the principal difficulties has been the enormous amount of ore-stealing by the Indians, who are remarkably ingenious in this respect. It is hoped that this will be materially lessened, as men once found out will be unable to get employment elsewhere, as was formerly the case. G. E. C.

METALLURGY OF SILVER IN CHILE.

Metallurgische Beiträge aus Chile. Das Auftreten der Silbererze zu Challacollo und deren Laugung zu Cerro gordo. By Andreas Gmehling. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli., pages* 468-471 *and* 479-483.

The mineral district of Challacollo lies at the foot of the Cordilleras, about 200 miles east of Patillas. The isolated range of Challacollo, rising about 1,000 feet above the Pampas, consists principally of quartz-trachyte. The principal veins run from south to north, and are cut through almost at right angles by subsidiary veins; the ore is usually richer at the point of junction. It is found as dry silver ore, and horn or chloride of silver, with a small proportion of barytes and lime. The barytes occurs as heavy spar, the lime chiefly as calcspar and gypsum. Lead sulphide or galena is found in bunches, but the quartz ore also contains lead carbonate, chloride, etc., which are rich in silver. Zinc oxide, carbonate and silicate of zinc, iron oxide, alumina, manganese, etc., are also present, impregnated with 10 per cent. of copper, and containing much silver and sometimes gold. The presence of iodine and sodium chloride or common salt, saltpetre, sulphates of magnesia and of iron seems to prove that the silver in the veins has been separated chiefly by a solution of common salt.

The mines have been sunk to a depth of 426 feet, and so far have not shown any variations in the character of the ore. At present only the six mines belonging to Messrs. Sotomayor, Carrasco, & Co., are commercially valuable. They contain four principal veins, those which crop up at the surface being richest in silver. The veins run from south to north with a dip west of 25 to 27 degrees, and thin out towards the south, where the main shaft is sunk. Better ore is found further north, and they are here concentrated at the surface for about 328 feet; as the ore is richer where the veins run together this vein has till now proved the most productive of any. The lodes are reached by galleries and shafts. The vein of ore is from 13 to 23 feet wide, and contains from 8 to 18 per cent. of silver. It is richest on the eastern side, where it is intersected by two cross veins running east and west, and forming a nucleus containing much silver. Towards the end of this vein a second shaft has been sunk. Throughout the mine, the vein of ore contains most silver on the east side, and is usually but not always richer where traversed by cross lodes. It never disappears, and is generally of considerable thickness, but its proportion of silver varies greatly, according to the inclination of the strata, and the occurrence of cross veins. To a depth of 262 feet, the principal vein is

nearly uniform, but it is then cut through by a quartz-trachyte cross lode, beyond which it is looser and not so compact. Wherever the ore is found in this loose and broken condition, it is poor in silver, containing only from 2 to 3 per cent. Below this, four veins can be distinctly traced, about 25 feet wide, more solid in composition, and with from 4½ to 6 per cent. of silver.

Extraction of the Ore.—The dry silver ore has a mean content of 10 per cent. of silver, principally in the form of chloride and iodide, and 0·0001 per cent. of gold. The chief silver-bearing minerals in the vein are:—Lead carbonate and galena, lead chloride, and a mixture of these with lead sulphate. Although the greater part of the silver is present as chloride or horn-silver, the ore is too compact to be treated in a raw state. To break it up and loosen the silver compounds a small quantity of salt is added, and the ore is then roasted in a revolving cylindrical kiln.

The composition of the ore fluctuates; during 1892 it was as follows:—Silver 9 to 12 per cent.; gold 0·00010 to 0·00015 per cent.; silica 75 to 84 per cent.; other minerals, such as lead, copper, zinc, manganese, in quantities varying from 7 per cent. to small traces, with a very minute percentage of moisture. It also contains rock-salt, saltpetre, sulphate of aluminium, iron, lime, magnesia, etc. In one sample these amounted to 4·25 per cent. Only about 7 to 12 per cent. of the silver and lead chloride can be dissolved in hot water, but much more is obtained with a 10 per cent. solution of cyanide of potassium. Of the horn-silver, 8·26 per cent. is set free in hot water; about 9·87 per cent. in a strong hot solution of salt; from 12·23 to 55 per cent. in solutions of hyposulphite of soda; 43·82 per cent. in ammonia solution, and 77·53 per cent. in a 10 per cent. hot solution of cyanide of potassium. The quantities vary according to the time allowed for dissolving, the best result being obtained after saturating the ore for 24 hours, and the lowest after 72 hours. By the process of amalgamation, from 60 to 70 per cent. of the silver can be extracted.

The ore from the Buena Esperanza mine, about 30 miles from Cerrogordo, is delivered in pieces of three sizes, the largest containing about 1 per cent., and the smaller sizes 8 and 6 per cent. of silver. There is no water in the mine, nor does it require any masonry or woodwork, the rock being firm, and the few props left here and there are scarcely necessary for safety. The ore is brought to the surface by a horse-gin; the working, raising, and separating costs from 8 to 9 pesos per ton. (The Chilian peso is constantly changing in value. At the present time, 1893, it is worth about 1s. 4d.; its nominal value is more than 4s.) The ore is then conveyed to Cerrogordo on carts drawn by mules, and holding about 2 tons each; the cost of transport is about 9 to 10 pesos per ton.

The larger pieces are broken small by hand, and are then delivered with the smaller to a ball crushing-mill, three of which are used at the mine. Each holds about 13¾ cwts. of cast-iron balls, makes 22 to 24 revolutions per minute, and delivers per hour from 17 to 27 cwts. of ore crushed fine enough to pass through a sieve. To grind this quantity 9 horse-power are required. Salt is fed in with the ore in the proportion of 8 per cent. It is next conveyed to rotating cylindrical kilns (Howell system), raised by an elevator into the kiln-hopper, and shot out automatically at the further end. The inclined cylinder is 27 feet long; it revolves half to one revolution per minute, and the ore is roasted in about an hour. From 98 to 107 cwts. of wood is required for firing per 24 hours, or from 49 to 53 cwts. of Australian coal. The wood costs 0·6 peso per cwt., and the coal 1·30 pesos per cwt., but wood is preferred, because combustion is more regular, and the walls are not burnt. It is found about 12 miles from Cerrogordo, covered

with sand to a depth of 3 feet. 16 pesos are paid on the spot per waggon-load of 29 to 35 cwts. of wood, and from 30 to 40 men are employed in digging it out.

Each furnace roasts in 24 hours from 686 to 744 cwts. of ore, which then falls into a brick chamber below, where it stands for some hours and becomes thoroughly chloridized. During roasting the ore swells and diminishes in weight and in proportion of silver, the loss depending chiefly on the temperature of the furnace. At a low temperature, the average loss in weight is 5·80 per cent., in silver 0·30 per cent.; and at a clear red heat, 10·40 per cent. and 31·82 per cent. respectively. To add more than 8 per cent. of salt to the ore is of no advantage. The ash is from 2 to 3 per cent., and contains almost the same proportion of silver as the ore, to which it is gradually added. One fireman is required, 1 man to bring the wood, and 1 boy to work the elevator. After roasting, the ore contains from 8 to 12 per cent. of soluble salts, and is best treated with a solution of 1 per cent. of hyposulphite, which extracts not only the silver, but whatever gold is present.

The crushed and roasted ore is next dissolved in troughs, 12 feet broad, 14 feet long, and 2¾ feet high, each containing a wooden filter covered with sacking, and holding 7½ tons. The ore, hot from the furnace, is poured into the troughs, and covered with water, which begins to boil immediately, and takes up the greater part of the soluble salts, principally common salt, and lead and silver chlorides. The height of water above the ore is 4½ inches, and about 247 cubic feet are needed for washing the ore the first time. As soon as the liquid ceases to boil, a plug below the filter is removed, and 153 cubic feet of water are run off, 94 cubic feet being absorbed and evaporated. The water discharged is at a temperature of 172 degs. Fahr. From 1½ to 2 hours are required for filtration.

The quantity of soluble salts dissolved in 1 litre (61 cubic inches) of water varies considerably; in the trough mentioned above, it was 4·3 ounces, with 7 grains of silver, or 65 ounces silver in 153 cubic feet of water. If the hot liquid be allowed to cool, the lead and silver chlorides fall to the bottom, being deposited in the same way as on the floor of the trough. The ore is then soaked in 159 cubic feet of fresh water, which take up 9½ ounces of silver; two hours are needed for this second process. All the water is then run into another trough, and the silver precipitated with sulphide of sodium. A considerable economy could be effected if the water were allowed to cool, and the silver naturally deposited. But this would require two days, and the quantities dealt with are so large that the simpler plan of precipitating the metal with sulphide of sodium has been preferred. The operation takes 1½ hours, and the sulphide obtained contains from 6 to 10 per cent. of silver. If time permitted, most of the lead, silver, copper, and iron could be separated from the water; but from 10 to 15 per cent. of the silver is generally left. Sulphide of sodium has been found the best and most economical precipitant, because all other methods entail loss in the extraction of the silver.

The ore remaining, after the water has filtered through it, is then dissolved six times in a solution of ½ per cent. of hyposulphite of soda. The separation of the silver chloride takes about as long as filtering. The first two infusions yield 102 ounces of silver; the next two, 34·8 ounces; the last two, 10¼ ounces of silver. Dissolving the ore thus takes 15 to 18 hours, the whole process, therefore, from the time the hot ore is first placed in the troughs occupies from 22 to 24 hours. The quantity of silver obtained from one trough holding 150 cwts. is as follows:—In the water, 76 ounces, or 30·65 per cent.; dissolved from the ore, 146·6 ounces, or 59·22 per cent.; total, 222·6 ounces. The ore contains 247 ounces of silver, therefore 24·4 ounces are lost, or 10·13 per cent.

The hyposulphite solutions are precipitated with sulphide of sodium. The deposition of the sulphur or metallic sulphide, containing 25 to 30 per cent. of silver and a little gold, takes 1½ to 2 hours; it is then dried and exported to Europe. Silver is also obtained by burning the old filters and sacks, the ashes of which contain from 8 to 12 per cent. of silver and a little gold. Formerly the wood and sacks, although impregnated with silver, were used to fire the boilers; 875 pounds of refined silver were obtained from them in the last half of 1892.

The sulphide having been precipitated, the hyposulphite solution is drawn off and pumped back to the vats through a layer of small ore, and in 2 or 3 months this ore absorbs from 4 to 8 per cent. of silver; it is then exported to Europe. In whatever way the ore is treated there is always a small unavoidable loss of silver, which has lately been considerably reduced, owing to the careful sifting of the refuse. In the latter half of 1892 about 5,106 tons of roasted ore were treated, with 9¼ per cent. of silver. In round numbers, the loss during precipitation may be taken at 12 to 14 per cent., but this is, of course, less, and the output more valuable, in working richer ore with 15 to 20 per cent. of silver.

The hyposulphite solution loses its strength during the working process by the decomposing influence of the air, the partial decomposition of the liquid, its dilution with water and saturation with other salts. The strength of the solution is therefore tested with iodine every day, and never allowed to fall below 4 per cent. For every ton of ore, from 2¼ to 2¾ pounds of hyposulphite are required. The troughs in which the silver is precipitated are of the same size as the filtering-troughs.

The sulphide left at the bottom of the troughs is washed, dried by the heat of the sun, and exported to Europe. The mean proportion of metals in this *sulfuros* or solid sulphide is:—Silver, 17 to 22 per cent.; gold, 0·010 to 0·018 per cent.; copper, 6 to 12 per cent.; lead, 10 to 20 per cent.; zinc, 5 to 12 per cent.; sulphur, 25 to 30 per cent.; and soluble salts, 13 to 16 per cent. Part of the sulphur can be separated by heating the metal with a solution of caustic soda, and the sulphide of sodium thus obtained may be again used to precipitate the silver.

The entire process of treating the ore after it has been brought to the surface costs from 18 to 22 pesos per ton. The price of silver has now (1893) fallen so low that it is just possible to make a small profit on ore containing 8½ per cent. of silver, if 8 troughsful are treated per day, or 833 to 930 tons per month. The cost of production depends also on the value of the Chilian peso; if the latter were suddenly to rise till it was worth about ⅔ ounce of silver, all metallurgical operations would necessarily have to be suspended.

Workmen's wages are high in this district, provisions and other necessaries are also very dear and much more expensive than in Europe. All these articles are supplied by the company working the mine, who keep a store and realize an average profit of 100 per cent. An ordinary day-labourer earns 3 pesos per shift; superior workmen, 4 pesos; foremen, 5 to 7 pesos. Mechanics, smiths, and carpenters are paid from 150 to 200 pesos per month; masons, 6 pesos a day. The head mechanic receives 250 pesos per month and his lodging; his assistants, 4 to 5 pesos a day; and the firemen the same. Piece-work is usual throughout the mine, and a skilful miner earns 120 to 150 pesos per month.

A list of prices of food and clothing is given in the original paper.

B. D.

THE ORE-DEPOSITS OF CREEDE, COLORADO, U.S.A.

By Thos. R. MacMechen. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii.*, *pages* 301-303, *with three ink photos of the Jimtown district.*

The author treats the subject under the following headings:—Geological formation, nature of the ore-deposits, the Last Chance-Amethyst vein, the Holy Moses vein, and Mammoth Mountain mines.

Referring to the Last Chance-Amethyst vein, he says this feature of the camp claims precedence because of its value at so early a stage of development. Along the surface, for a distance of over 1,100 feet, it has been exposed to a depth of 150 feet by drifts on the vein connecting the entire body, and during the time of exploration not more than 4 tons of waste rock were extracted. This development showed the existence of a vein of an average width of 6 feet. The average grade of the ore-body is from about £16 to £32 per ton. Upon a cautious estimate, says the author, about £300,000 worth of ore is in sight above the 100 feet level, and the heaviest body in the Amethyst vein is displayed in the north drift. Below the 100 feet level and between the two shafts, located about 200 feet apart on the vein, from £160,000 to £200,000 worth of ore is expected to be mined. J. W.

THE ORE-DEPOSITS OF CREEDE, COLORADO, AND THEIR POSSIBILITIES.

By Edmund B. Kirby. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii.*, *pages* 325-326.

The author had examined the geology and ore-deposits at this silver-camp in the latter part of September, just before the heavy snowstorm stopped geological surface-surveying for the winter.

A description of the geological features is given, also of the veins. The quantity of silver in the large bodies (8 to 20 feet thick in the Holy Moses vein) is said to be 10 to 15 ounces per ton, but large streaks and patches through the mass are high grade, bearing 50 to 100 ounces per ton, and these constitute the shipments sent to market. This pay-ore is distinguished from the mass only by assay. It is nearly free from lead and gold. A quartz streak occurs, but is said to be low in silver, so the mining is mainly the development of the high-grade ore streaks in the soft hanging-wall.

The present rate of shipment from the district is 150 to 175 tons of ore daily; 100 tons of this being from the Last Chance, and the rest from the Amethyst, Holy Moses, and Ethel mines in the order named. This, says the author, is a remarkable record, and justifies large expectations for the future.

The short period of five months, in a winter with heavy snowfall, has seen the advent of the railroad, the shipment of some 8,300 tons of high-grade ore, and a rush to the district that has increased the population from 200 to 7,000 men. J. W.

THE BROKEN HILL SILVER-MINES, NEW SOUTH WALES.

By T. A. Rickard. *Engineering and Mining Journal (New York)*, 1891, *vol. lii., pages* 530-532.

Broken Hill, reached by 300 miles of railway from Adelaide (South Australia), but inside the New South Wales border, is in the Barrier Ranges, which were known as a rich but patchy mineral-field long before the discovery of the silver deposits which have lately made them famous. It was a cowboy or "boundary rider" who first discovered silver where he thought a tin-mine might possibly be commenced. This was in September, 1883, since when the said cowboy and his fellow-stockmen have become millionaires. The development of the mines has been carried on till an output of from 175,000 to 200,000 ounces of silver per week has been attained.

As seen from the mine, the surrounding country is of dreary flatness, broken only by occasional low hills. The outcrop of the lode forms a black ridge of manganic ironstone, whose irregular contour gives the name of Broken Hill. Close at hand extends the town of Broken Hill with its population of 30,000.

Connected with the big mine—the Broken Hill Proprietary—are 13 furnaces, the output of this plant being a ton of silver per day.

The following figures give the annual yield of the Broken Hill field up to the close of 1890:—Prior to December, 1887, 10,378,883 ounces; for the year 1888, 4,020,370 ounces; 1889, 6,358,463 ounces; 1890, 7,824,605 ounces.

The Broken Hill Proprietary mine is the largest and has the largest output. Up to the date of the last report, 654,873 tons of ore had been treated, producing 25,729,834 ounces of silver and 107,037 tons of lead, having a total value of £5,893,722.

Up to the close of last year the average value per ton of ore was £9 7s. 7d.; the average cost £4 7s. 9d., and the average profit £5 1s. 10d.

The mine is worked by means of eight principal shafts, the bulk of the stoping so far done being confined to that part of the mine which is above the second level.

The lode as seen at the No. 2 level, whose average distance from the surface is 215 feet, is of extraordinary size and value.

More so perhaps than any other modern silver mine, the Broken Hill Proprietary is enriched by a varied assortment of silver-bearing minerals scattered in splendid profusion through the ore. Block XI. is especially remarkable. There is there an ore-body 270 feet long, averaging 200 feet in width and carrying from 50 to 55 ounces of silver per ton, together with 30 per cent. lead. The candle-light shows large faces of manganic ironstone studded with the half-formed crystals of iodide and chloride of silver, the two being readily distinguishable by their colour. In the third level, the sulphide ores are of low tenor and a very refractory character, containing for the most part from 16 to 18 ounces of silver, and 25 to 30 per cent. of lead, mixed with a large percentage of blende and occasionally pyrites. The sulphides are loose and friable, the coarser crystalline galena is richer than the fine-grained, and carries as a maximum 60 ounces of silver.

The great question which arises sooner or later in so many silver-fields, that of the replacement of easily reducible oxidized ores by more or less refractory sulphides, has already arisen at Broken Hill. Galena, blende, and garnetiferous sandstone form ore of a discouragingly refractory character. When its silver contents are low the question of its economical treatment is one which will try the resources of the ablest metallurgist. At the present time strenuous attempts are, with the enterprise characteristic of the company, being made to solve the problem.

J. W.

THE EICHLER DOUBLE WATER-TIGHT PILING.

Neue hohle doppelwändige, glatte und wasserdichte Spundwand. ANON. *Glückauf*, 1895, *vol. xxxi., page* 931, *and* 6 *figures in text.*

The Eichler piling system is suitable for lining circular or multi-angular shafts or galleries in water-bearing strata, and keeping out loose sand, for excavating for foundations or bridge-piles, especially where ramming or shocks must be avoided; in breakwaters or sea-walls, either as a protective work or as a wall filled with concrete; and if perforated and the internal space filled with gravel, makes an excellent filter-casing for wells.

The materials employed in its construction may be either wrought or cast-iron, or a combination of the former with wood. Each section or pile is formed of two similar pieces, about 12 feet long (either of iron plate fitted with an iron bracket, or of a single piece turned up to form an angle), placed side by side, and fastened together by stayed bolts. A completed section has flat surfaces on both inner and outer sides, and by means of a groove left open at both ends, it can be interlocked with the corresponding portions of the adjacent sections, the edges fitting into suitable recesses, and thus forms a strong joint, which external pressure only assists to preserve. The iron-plate employed varies from $\frac{1}{32}$ to $\frac{1}{2}$ inch in thickness, 12 feet in length, and about 10 inches wide, with suitable iron brackets placed at one side. Two sections, when placed together, may have an external thickness of 3 to 4 inches or more, according to requirements. Wooden piles are cheaper than iron, and are made of planks $1\frac{1}{4}$ to $1\frac{1}{2}$ inches thick, but the dimensions, both of these and of the iron piles, can be increased, if desired, by using thicker plates, or by bolting several lengths together. The lower end of the section-plates may be protected with iron-shoes if necessary, but usually filing down the plate to a feather-edge will suffice.

The fixing the piles in position may be effected by means of a ram, jack, or hydraulic press, according to the nature of the ground, the sections being placed in juxtaposition and driven in, although not at equal depths, until the work is completed.

C. S.

METHOD OF PLUMBING SHAFTS.

By A. NEUSTAEDTER. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxi., pages* 792-794.

The writer here describes a method of plumbing shafts which he has used with good results. It consists in obtaining a longer base by suspending the plumb-lines from the extreme corners, lengthwise of the oblong shaft, and reproducing the bearing by offset-points on sticks attached to plumb-lines and supported on floating corks.

A. W. G.

METALLURGY OF IRON PYRITES.

Die Kupferdarstellung aus gerösteten Kiesen. By ROB. SCHELLE. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli., pages* 517-522 *and* 531-534, *and* 2 *plates.*

Sulphuric acid, which till within the last 50 years was extracted from sulphur only, is now chiefly obtained by roasting pyrites. Treated by the dry process, the pyrites was useless unless rich in different metals; now the raw material represents a valuable product, even if it contains nothing but iron. At first, copper pyrites was roasted to produce sulphuric acid, and the copper and other

metals were separated by smelting. As the price of sulphur rose, iron pyrites was used for its extraction, and a much larger residuum, containing iron, copper, and silver, remained after roasting to be dealt with. This could not be treated by the dry process of smelting, on account of the expense. The wet process was therefore adopted, namely, the separation of the copper, silver, and sulphur in the roasted pyrites by dissolving with water and salt, and the subsequent utilization of the iron.

The first experiments were made in England, and the method there introduced is now universally employed. There are various places in Germany and Austria where iron pyrites after roasting for sulphuric acid is treated in this way, sometimes native, sometimes Spanish pyrites being used. The composition of the pyrites varies greatly, especially in its proportion of copper. Spanish pyrites is richer than Hungarian, but never contains more than 3 to 4 per cent., ore with a higher percentage of copper not being exported. The poorer pyrites is sent over in shiploads to the sulphuric-acid works in Germany and England, and thence to the copper-refineries. Hungarian pyrites contains less copper and more silver, iron, and sulphur than the Spanish. The proportions are:—In the Hungarian, 40 per cent. of sulphur, 40 per cent. of iron, ½ to 2 per cent. of copper, and 0·0055 per cent. of silver. In the Spanish, 48 per cent. of sulphur, 40 per cent. of iron, 4 per cent. of copper, and 0·003 per cent. of silver. Two million tons of pyrites are brought annually from Spain and England, and 30,000 to 40,000 tons are obtained from a mine in Hungary.

In the roasted products, or pyrites from which the sulphur has been extracted, iron is present as oxide, copper as a metal, oxide, or sulphide, which cannot be dissolved in water only. To extract it the following processes, mostly mechanical, are employed:—Pulverizing, roasting, lixiviating, or impregnating and dissolving with salt, separating the silver and copper, and working up the precipitated copper.

As the roasted pyrites is brittle, it is easily pulverized, and must be crushed fine enough to pass through a sieve with holes ⅛ inch square. Salt is added, the quantity varying according to the percentage of copper and sulphur. A certain amount of sulphur is necessary, otherwise it is impossible to chloridize the copper; the proportion should be about 1½ times that of the copper. The proportion of salt is from 7 to 20 per cent.

The pyrites is then roasted, to render the copper soluble in water, or in diluted sulphuric or muriatic acid. Some pyrites, especially Portuguese, is so brittle, and the copper so equally distributed throughout, that no roasting is necessary. It is sufficient to soak it several times in the original solution, until the copper is dissolved. Usually, however, the pyrites is too solid to be treated thus, and must be roasted with salt. With ordinary roasting and a low furnace-temperature, more copper is dissolved, and the solution contains more iron; at a higher temperature, the copper is not completely dissolved, a large quantity of sulphur is left in the pyrites, and iron cannot be obtained from it. But if salt be added, and the pyrites instead of being oxidized is chloridized by roasting, a different and much more favourable result is produced. A high temperature is then of advantage, and the greater part of the copper may be extracted, with very little iron. Part, however, is transformed into insoluble oxide and chloride, and therefore the higher the temperature of the furnace during roasting, the larger the quantity of copper obtained.

At first ordinary furnaces were used, but were found unsuitable, because the temperature was not uniform, and the gases of combustion mingled with the

chlorine and hydrochloric acid vapours, and made them difficult to condense. In the two types used chiefly in Lancashire and Hungary, the gas flames are first introduced below the furnace charged with the pyrites, and then carried over it, the air necessary for combustion entering separately. Two and a half tons of pyrites can be treated in 24 hours in one of these furnaces. Their disadvantage is that the hydrochloric acid gas generated becomes mixed with the gases of combustion, and can with difficulty be condensed. Vaulted furnaces have therefore been adopted in the larger Austrian chemical works. In these the flames do not come into contact with the pyrites, but the latter are heated in a separate chamber.

A furnace of this kind has in the centre a vaulted space, the floor of which, charged with pyrites previously dried and heated, rests upon the double grate. Air is separately admitted. The flames are carried first above, then below the vaulted chamber, and the products of combustion led off into the chimney. The gases generated from the pyrites during roasting are conveyed to a condenser. These furnaces require more fuel than the others, but as the temperature is low, an even heat is maintained, upon which the extraction of the copper depends. Other furnaces, mostly used in England, combine the two systems. The flames do not come into direct contact with the pyrites, but pass over a wall built half way across the furnace, the roof of which slopes upward. The best type has a circular rotating iron floor, lined with firebrick, and is fixed in the bottom of an ordinary vaulted furnace. The combustible is fired in a separate grate at the side, but the flames pass on to the circular floor, on which the pyrites is placed, mingle with the gases generated, and are carried off to the condenser. The floor is fixed on a vertical axis, and is rotated by means of an endless chain. The pyrites is mixed, distributed, and withdrawn from the furnace by machinery. The air necessary for combustion is separately introduced. At the Bede metal works, 12 of these furnaces are in use, worked by a 12 horse-power steam engine, and all the parts except the mixer last a long time.

With an ordinary furnace the charge of pyrites is from 2 to 2½ tons, and is spread over the floor to a depth of 4 to 5½ inches. The furnace is then heated to a dark red, the pyrites being kept continually mixed, the roasted mineral periodically withdrawn, and the heat maintained uniform. Blue flames appear, and after about 5 hours, the burning pyrites becomes of a greenish-grey colour, and the process of roasting is complete. The charge is then emptied into the troughs, and the copper contained in the pyrites dissolved in water; 75 per cent. can be thus obtained, 20 per cent. dissolved with muriatic acid, 5 per cent. with nitrate, and 5 per cent. is usually wasted. The time of roasting varies with the amount of sulphur and copper in the pyrites. To roast poor pyrites in a revolving furnace takes 6 hours; rich pyrites in ordinary furnaces, 10, 12, or 15 hours. Cheap coal is used for firing. In the Duisburg metal works there are 12 vaulted furnaces, in which Spanish pyrites are roasted 8 to 10 hours with 15 per cent. of salt; each charge weighs 2½ tons. At Hemixen in Belgium, 5 tons of Swedish pyrites are roasted at a time for 6 hours, with 20 per cent. of salt, and 170 lbs. of fuel are burnt per ton of pyrites. The temperature of the furnace varies from 752 to 932 degs. Fahr. Sometimes from 5 to 7 per cent. of sulphate of iron is added to the salt, and reduces the time of roasting by one-third. It is said that 96 per cent. of the copper can afterwards be dissolved out with water alone, and no hydrochloric acid is necessary. Of the copper, 3·25 per cent. is obtained if the pyrites be roasted in the ordinary furnace, 3·53 per cent. if roasted in a revolving furnace.

The gases are condensed in the same way as the gases from sulphur furnaces used in the manufacture of soda. They are led into isolated towers of brick,

bound with mortar made of tar and sand, and filled with coke or firebrick, over which water runs continually to absorb the hydrochloric acid gas. Smaller towers may be used with vaulted furnaces, and condensation is said to be more rapid if the walls are thin. Most of the acids thus obtained are required to dissolve the chloride of copper from the pyrites.

The roasted and chloridized pyrites is then heated in troughs and lixiviated, or dissolved out with salt and water. The troughs, 10 to 13 feet long and 5 to 6 feet deep, are of wood, lined with tar or asphalt, with filters at the bottom. The pyrites is first soaked in cold water or a weak copper solution, then twice dissolved in boiling water. The solution thus formed contains all the copper compounds soluble in water, and 95 per cent. of the silver. It is then dissolved in six solutions of diluted hydrochloric acid, unless it has been roasted in revolving furnaces, when nearly all the copper present is soluble in water. The process lasts two days, and each trough is reckoned to yield about 5 tons of dissolved pyrites per day. Of these six solutions the first is the original weak copper solution, which, after standing some time, loses part of its lime and sodium salts by evaporation. The others are formed with water from the condensing tower, impregnated with acid. The extent to which the different metals are dissolved in the solution varies according to the type of furnace used. If the pyrites be roasted in ordinary furnaces, about 1·94 per cent. of the copper is soluble in water, in rotary furnaces 2·77 per cent., the total proportion of copper being about 3 per cent.

Three products are thus obtained—two solutions and an insoluble residuum, containing 90 to 95 per cent. of ferric oxide, and utilized in ironworks under the name of purple ore or blue billy. The proportion of iron is from 63 to 66 per cent.; Spanish pyrites yields the best residuum. It is used to feed puddling-furnaces and for fusing metals.

Chloride of silver is found in the first solution, to which a little salt is sometimes added. The silver is usually separated by the Claudet method, but the process varies in different works. It is precipitated in the form of iodide of silver, by means of a soluble metal iodide, after the solution has become clear by standing. As the silver floats in the fluid in such minute particles that it takes a long time to settle, various means are used to hasten the process. These are generally kept secret, but mainly consist in the addition of sugar of lead, glue, tannic acid, or some other substance which settles quickly, and carries down with it the fine iodide of silver. The deposit thus obtained, containing iodides of lead and silver, and sulphate of lead, is variously treated with hydrochloric acid, zinc, sulphide of sodium, etc., the aim of all the methods being to separate the iodine so that it may be used again. A composite metal is produced, containing about 6 per cent. of silver, which is seldom worked on the spot, but is usually sent to the silver refineries at Hamburg and elsewhere. In the Gibb process, 6 per cent. of the copper is separated from the first solution by sulphuretted hydrogen, and almost all the silver is found in it. Most of the silver can also be extracted if 19 per cent. of the copper be separated from the solution with iron. Another method is to extract the copper and silver by electrolysis.

In precipitating the copper, if the water solutions obtained from the pyrites are treated alone, copper of the best quality is produced from them, and simply refined after smelting. Generally, however, the water and acid solutions are mixed, and the copper separated with scrap-iron in troughs, steam being used to precipitate it. The time required for the process varies; the quantity of iron is generally 1 part by weight to 1 of copper. The composition of the precipitated copper varies

according to the quality of the pyrites, the purity and quality of the iron used, and the strength of the solution. In Belgium it contains nearly 76 per cent. of pure copper, in Silesia 80 per cent., and small quantities of iron, silver, etc.

The copper obtained from the water solutions alone may, with the addition of chalk, slag, etc., be melted down into coarse copper in an ordinary furnace. If the copper be impure, sulphur must be added to it, and the mixture again roasted and smelted; while if it contains much carbon part must be oxidized by roasting, the carbon burnt, and the copper smelted afterwards with the same quantity of unburnt copper. Generally, however, the whole of the precipitated copper, whatever its quality, is smelted all together in ordinary refining-furnaces.

In smaller works blue vitriol, not coarse copper, is produced from the precipitated metal. The iron compounds are transformed, by roasting, into iron oxide. In Bohemia, the copper and silver from the first water solution are separated, and the precipitated copper is freed from the silver by the Philipp system. Salt, both raw and in a hot solution, is used to convert the copper into oxide, and the silver into chloride. Another and better method is to smelt the copper and separate the two metals electrolytically; copper of the finest quality is thus obtained, and all the silver settles as slag. After the copper has been deposited, the solution contains principally iron and sulphate of soda, and cannot at present be utilized, because of the expense of separating the iron. B. D.

RECENT ADVANCES IN PYROMETRY.

By W. C. Roberts-Austen. *Transactions of the American Institute of Mining Engineers*, 1893, *vol. xxiii.*, *pages* 407-443.

The earliest pyrometers were essentially thermoscopes, and although their graduation presented great difficulties, their importance for the measurement of high temperatures has been recognized for centuries.

The author gives a brief history of pyrometers from their commencement. In 1886, very distinct advances in practical pyrometry were made, and Mr. Callendar and Mr. Le Chatelier then brought out their pyrometers. Sir William Siemens' instrument was brought out in 1860, and was the first to use the electrical resistance of a heated metallic conductor for measuring high temperatures. The Le Chatelier instrument was the first to use a platinum-rhodium couple. Photography is used for recording the temperature employed in conducting metallurgical operations.

The calorimetric method of Mr. Violle gave very trustworthy results, which are used for graduating other forms of pyrometers.

The pyrometric alloys used by Mr. Prinsep in 1827 were too cumbersome and difficult for ordinary use.

The Le Chatelier photometric instrument and the optical pyrometer of Messrs. Nouel and Mesuré are figured and described.

It is an important point to know to what extent the indications of different pyrometers are concordant, and to this end Prof. Barns devised an apparatus for comparing the air-thermometer with the thermo-couple, and the results he obtained agreed remarkably well. Prof. Barns also invented a method depending on the viscosity of gases.

Of the various forms of pyrometers described, the author is in favour of the electrical ones, which involve the use of the galvanometer. A. W. G.

METRIC CONVERSION TABLES.

I.—Tables for Converting British to Metric Weights and Measures.

	Linear.				Capacity.			
	Inches to Millimetres.	Feet to Metres.	Yards to Metres.	Miles to Kilometres.	Fluid Drams to Millilitres or Cubic Centimetres.	Fluid Ounces to Millilitres.	Imperial Quarts to Litres.	Imperial Gallons to Litres.
1	25·3995	0·304794	0·914383	1·60931	3·54	28·39	1·13586	4·54345
2	50·7991	0·609589	1·828767	3·21863	7·09	56·79	2·27173	9·08691
3	76·1986	0·914383	2·743150	4·82794	10·64	85·19	3·41759	13·63037
4	101·5982	1·219178	3·657534	6·43726	14·19	113·58	4·54346	18·17383
5	126·9977	1·523972	4·571917	8·04657	17·74	141·98	5·67932	22·71728
6	152·3972	1·828767	5·486301	9·65589	21·29	170·38	6·81519	27·26075
7	177·7968	2·133561	6·400684	11·26520	24·84	198·77	7·95105	31·80421
8	203·1963	2·438356	7·315068	12·87452	28·39	227·17	9·08692	36·34766
9	228·5959	2·743150	8·229451	14·48383	31·94	255·57	10·22278	40·89112

	Square.				Cubic.				Pounds per Square Inch to Kilogrammes per Square Centimetre.
	Square Inches to Square Centimetres.	Square Feet to Square Decimetres.	Square Yards to Square Metres.	Acres to Hectares.	Cubic Inches to Cubic Centimetres.	Cubic Feet to Cubic Metres.	Cubic Yards to Cubic Metres.	Bushels to Hectolitres.	
1	6·451	9·290	0·836	0·4047	16·386	0·02832	0·765	0·36347	0·07030
2	12·903	18·580	1·672	0·8093	32·772	0·05663	1·529	0·72695	0·14061
3	19·354	27·870	2·508	1·2140	49·159	0·08495	2·293	1·09043	0·21092
4	25·805	37·160	3·344	1·6187	65·546	0·11326	3·058	1·47391	0·28123
5	32·257	46·450	4·180	2·0233	81·931	0·14158	3·823	1·81738	0·35154
6	38·708	55·740	5·017	2·4280	98·317	0·16989	4·587	2·18086	0·42185
7	45·160	65·030	5·853	2·8327	114·703	0·19821	5·352	2·54434	0·49215
8	51·611	74·320	6·689	3·2374	131·089	0·22652	6·116	2·90781	0·56246
9	58·062	83·610	7·525	3·6420	147·476	0·25484	6·881	3·27129	0·63187

	Weight.				
	Grains to Milligrammes.	Avoirdupois Ounces to Grammes.	Troy Ounces to Grammes.	Avoirdupois Pounds to Kilogrammes.	Avoirdupois Tons to Metric Tonnes.
1	64·7989	28·3495	31·10349	0·45359	1·01605
2	129·5979	56·6991	62·20699	0·90719	2·03210
3	194·3968	85·0486	93·31049	1·36078	3·04814
4	259·1958	113·3982	124·41398	1·81437	4·06419
5	323·9947	141·7477	155·51748	2·26796	5·08024
6	388·7937	170·0972	186·62098	2·72156	6·09628
7	453·5926	198·4468	217·72447	3·17515	7·11233
8	518·3916	226·7963	248·82797	3·62874	8·12838
9	583·1905	255·1458	279·93146	4·08233	9·14443

Miscellaneous.

1 inch	= 25·39954113188991 millimetres.
1 foot	= 0·304794493582 metre.
1 yard	= 0·914383480748 metre.
1 fathom	= 1·829 metres.
1 chain	= 20·116436576456 metres.
1 mile	= 1·6093149261 kilometres.
1 square inch	= 6·451366897 square centimetres.
1 square foot	= 0·092899683 square metre.
1 square yard	= 0·836097149 square metre.
1 square mile	= 259 hectares.
1 avoir. pound	= 453·592652546 grammes.
1 gallon	= 4·54345797 litres.
1 bushel	= 36·34766376 litres.

II.—Tables for Converting Metric Weights and Measures to British.

	Linear.				Capacity.				
	Metres to Inches.	Metres to Feet.	Metres to Yards.	Kilometres to Miles.	Millilitres or Cubic Centimetres to Fluid Drams.	Centilitres to Fluid Ounces.	Litres to Imperial Quarts.	Decalitres to Imperial Gallons.	Hectolitres to Imperial Bushels.
1	39·37	3·28090	1·093633	0·62138	0·28	0·352	0·8804	2·2010	2·7512
2	78·74	6·56180	2·187266	1·24276	0·56	0·704	1·7608	4·4019	5·5024
3	118·11	9·84270	3·280899	1·86415	0·84	1·056	2·6412	6·6029	8·2536
4	157·48	13·12360	4·374532	2·48553	1·13	1·409	3·5215	8·8039	11·0048
5	196·85	16·40450	5·468165	3·10691	1·41	1·761	4·4019	11·0048	13·7560
6	236·22	19·68540	6·561798	3·72829	1·69	2·113	5·2823	13·2058	16·5073
7	275·59	22·96629	7·655431	4·34968	1·97	2·465	6·1627	15·4068	19·2585
8	314·97	26·24719	8·749064	4·97106	2·25	2·817	7·0431	17·6077	22·0097
9	354·34	29·52809	9·842697	5·59244	2·53	3·169	7·9235	19·8087	24·7609

	Square.				Cubic.				
	Square Centimetres to Square Inches.	Square Metres to Square Feet.	Square Metres to Square Yards.	Hectares to Acres.	Cubic Centimetres to Cubic Inches.	Cubic Decimetres to Cubic Inches.	Cubic Metres to Cubic Feet.	Cubic Metres to Cubic Yards.	Cubic Metres to Imperial Gallons.
1	0·155	10·764	1·196	2·471	0·0610	61·027	35·316	1·308	220·097
2	0·310	21·529	2·392	4·942	0·1220	122·054	70·633	2·616	440·193
3	0·465	32·293	3·588	7·413	0·1831	183·081	105·950	3·924	660·290
4	0·620	43·057	4·784	9·885	0·2441	244·108	141·266	5·232	880·387
5	0·775	53·821	5·980	12·356	0·3051	305·135	176·583	6·540	1100·483
6	0·930	64·586	7·176	14·827	0·3662	366·162	211·899	7·848	1320·580
7	1·085	75·350	8·372	17·298	0·4272	427·189	247·216	9·156	1540·677
8	1·240	86·114	9·568	19·769	0·4882	488·216	282·533	10·464	1760·773
9	1·395	96·879	10·764	22·240	0·5492	549·243	317·849	11·772	1980·870

	Weight.							
	Milli-grammes to Grains.	Kilogrammes to Grains.	Hecto-grammes to Avoir-dupois Ounces.	Kilogrammes to Avoirdu pois Pounds.	Quintals to Avoir-dupois Pounds.	Tonnes or Milliers to Avoir-dupois Pounds.	Grammes to Troy Ounces.	Tonnes to Tons.
1	0·01543	15432·35	3·5274	2·20462	220·46	2204·6	0·03215	0·9842
2	0·03086	30864·70	7·0548	4·40924	440·92	4409·2	0·06430	1·9684
3	0·04630	46297·04	10·5822	6·61386	661·39	6613·9	0·09645	2·9526
4	0·06173	61729·39	14·1096	8·81848	881·85	8818·5	0·12860	3·9368
5	0·07716	77161·74	17·6370	11·02311	1102·31	11023·1	0·16075	4·9210
6	0·09259	92594·09	21·1644	13·22773	1322·77	13227·7	0·19290	5·9052
7	0·10803	108026·44	24·6918	15·43235	1543·24	15432·3	0·22505	6·8894
8	0·12346	123458·79	28·2192	17·63697	1763·70	17637·0	0·25721	7·8736
9	0·13889	138891·14	31·7465	19·84159	1984·16	19841·6	0·28936	8·8579

Miscellaneous.

1 millimetre	=	0·03937079 inch.
1 metre	=	39·37079 inches.
	=	3·28089916 feet.
	=	1·09363305 yards.
1 kilometre	=	0·62138241792 mile.
1 square centimetre	=	0·1550059105 square inch.
1 square metre	=	10·76429934 square feet.
	=	1·19603326 square yards.
1 hectare	=	2·4711430996 acres.
1 cubic centimetre	=	0·061027 cubic inch.
1 cubic metre	=	35·31658074 cubic feet.
1 litre	=	61·0270515 cubic inches.
	=	0·22009668 gallons.
1 kilogramme	=	15,432·34874 grains.
1 tonne or millier	=	0·984205914 tons.

M. W. B.

LIGNUM VITÆ FOR AXLE-BOXES.

Pockholz im Maschinenbau. Anon. *Dingler's Polytechnisches Journal*, 1893, *vol. ccxc., page* 288.

Lignum vitæ has been found, by direct experiment at the Conservatoire des Arts et Métiers at Paris, to withstand about one and a half times as much pressure as oak. Experiments on its frictional resistance have also been made. Two axle-boxes were taken, one fitted with ordinary brasses, and the other with lignum vitæ bearings. The frictional resistance of the first being taken as 1, that of the second was (1) 0·661, (2) 0·748, and (3) 0·785, each being loaded with (1) 220·4 lbs., (2) 330·6 lbs., and (3) 440·8 lbs. respectively. The ordinary bearings were also found to be heated, while the wooden ones remained cool. In spite of this low coefficient of friction the author finds that lignum vitæ is also good for brake blocks.

W. M.

THE HANARTE VENTILATOR.

Le Ventilateur Hanarte. By G. Hanarte. *Publications de la Société des Ingénieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut*, 1893, *vol. iii., pages* 4-7.

A Hanarte ventilator has been erected at the Ste. Julie pit of the Vingt-quatre-actions collieries. The following table contains the results of experiments:—

	Hanarte.	
	No. 1.	No. 2.
Diameter of ventilator, feet	9·84	13·12
Width of ventilator, inches	13·39	13·39
Volume or contents of ventilator, cubic feet	85	85
Revolutions per minute, engine	43	50
,, ,, ventilator... ...	129	150
Volume per revolution, cubic feet	119	130
Ratio of volume of fan to volume of air produced per revolution	1·40	1·53
Water-gauge, inches	1·575	1·968
Volume of air per minute, cubic feet ...	15,370	19,460
Area of place of measurement, square feet...	27·3	27·3
Velocity at place of measurement, per minute, feet	563	713
Dimensions of engine, inches	12·6 × 20·5	12·6 × 20·5

When air was freely admitted from the atmosphere, the volume produced by the fan was 36,800 cubic feet per minute under a water-gauge of 0·591 inch, at 44 revolutions of the engine and 132 of the ventilator per minute, and exhausted 3·29 times its volume per revolution. M. W. B.

THE MEASUREMENT OF WIRE ROPES.

By A. S. Hallidie. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii., page* 426.

A custom has obtained of measuring ropes by their diameters, and as a consequence many disputes have arisen between the seller and buyer regarding the actual size of such ropes. The method that has generally prevailed, heretofore, has been to measure ropes by their circumference, and this custom is still in use where ordinary technical or business accuracy is required, and no other way of measuring a rope can be relied on for accuracy and fairness. This applies equally to all kinds of ropes, whether three, four, or six-stranded.

Take for example a rope made of six strands ; there being no accepted rule as to where the diameter shall be measured, it may be taken at any part of the circumference of the hexagon formed by the six strands. Hence it is much more satisfactory to measure the circumference of the rope ; but here again there is a possibility of unfairness, in the absence of a defined method of measurement. The best way, according to the author, is to take a piece of ordinary writing paper, about $\frac{1}{4}$ inch wide, wrap it round the rope, and cut it off with a sharp knife at the overlap. This will give the circumference measured on the faces of the hexagon, and determine exactly the size of the rope.

Each division of space of the circumference being 3·1416 times that of the diameter, the circumference measurement is three times as accurate, and in every way, both as to fairness, accuracy and simplicity, this method is to be preferred.

J. W.

II.—BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1894.

By M. WALTON BROWN.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32 degs. Fahr.

The statistics of fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are also printed upon the diagrams (Plates XXVIII. and XXIX.) recording the meteorological observations.

Deaths from Explosions of Fire-damp during 1894, in the several Inspection Districts.

	Deaths.
Durham ...	2
Liverpool	0
Manchester	1
Midland ...	0
Newcastle-upon-Tyne	1
Scotland, East ...	1
Do. West ...	5
South Wales	295
South-Western ...	0
Staffordshire, North	1
Do. South	8
Yorkshire	3
Total ...	317

List of Fatal Explosions in Collieries during 1894.

1894.	Colliery.	District.	Deaths.
Jan. 1, 1·30 a.m. ...	Gorseinon	South Wales	1
Mar. 23, 3· 0 p.m. ...	Ayr-Sundrum (No. 3)	Scotland, West ...	1
April 18, 6· 0 ,, ...	Portland (No. 5) ...	Do. do. ...	1
May 19, 12· 0 ,, .	Allerton Main... ...	Yorkshire	3
June 23, 3·50 ,, ...	Albion	South Wales	290
Aug. 1, 12·30 ,, ..	Llwynpia (No. 3) ...	Do.	1
,, 8, 5· 0	Bank House	Manchester	1
,, 9, 5· 0 ,, ...	Rowley Hall	Staffordshire, South ...	1
.. 17, 6·30	Black Boy	Durham	1
Sept. 6, 2·30 ,, ..	West Auckland ...	Do.	1
,, 10, 7·30 a.m. ...	Radcliffe	Newcastle-upon-Tyne	1
,. 21, 12·15 p.m. ...	East Cannock ...	Staffordshire, South ...	1
,, 26, 2·30 ,, ...	Wednesbury	Do. do.	1
,, 27, 9· 0 a.m. ...	International Anthracite	South Wales	1
Oct. 15, 4· 0 p.m. ...	Common (No. 10) ...	Scotland, West ...	1
,. 16, 5·30 ,, ...	Harecastle and Woodshutts colliery, Moss pits	Staffordshire, North ...	1
,, 17, 7·15 a.m. ...	Ellismuir (No. 2) ...	Scotland, West ..	1
,, 25, 11· 0 p.m. ...	Blairhall	Scotland, East ...	1
,, 27, 8· 0 a.m. ...	Common (No. 14) ...	Scotland, West	1
,, 27, 7·30 p.m. ...	Sandwell Park ...	Staffordshire, South ...	4
Nov. 10, 9·30 a.m. ...	Gadlys, Dyllas ...	South Wales	2
., 22, 2·30 p.m. ...	Ashmore Park... ..	Staffordshire, South ...	1
		Total	317

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	KEW.							GLASGOW.							
	Barometer.				Tempera-ture.				Barometer.				Tempera-ture.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·307	30·304	30·242	30·239	37·9	32·4	N	1	30·430	30·444	30·403	30·396	41·6	29·5	W
2	30·182	30·182	30·282	30·396	36·9	26·3	NNE	2	30·369	30·386	30·459	30·577	36·3	27·8	ENE
3	30·457	30·543	30·511	30·436	30·2	26·7	ENE	3	30·615	30·676	30·671	30·658	34·6	31·1	E
4	30·336	30·224	30·060	30·006	29·0	16·9	NE	4	30·598	30·590	30·382	30·265	34·3	31·2	NE
5	29·827	29·820	29·681	29·677	22·2	14·0	ESE	5	30·145	29·987	29·779	29·626	35·0	28·9	E
6	29·626	29·612	29·636	29·713	26·5	21·6	NNE	6	29·479	29·584	29·592	29·638	30·1	16·7	E
7	29·777	29·893	29·950	30·041	25·1	20·1	E	7	29·669	29·722	29·770	29·875	33·8	15·6	ENE
8	30·069	30·038	29·942	29·895	36·8	30·7	E	8	29·914	29·919	29·817	29·707	34·3	25·7	E
9	29·797	29·784	29·753	29·816	38·5	31·7	SE	9	29·592	29·621	29·642	29·656	40·3	31·1	NE
10	29·825	29·834	29·845	29·836	48·1	30·0	S	10	29·468	29·378	29·518	29·467	49·1	35·8	S
11	29·823	29·875	29·865	29·803	51·3	39·9	SSW	11	29·399	29·346	29·578	29·632	50·9	44·6	S
12	29·768	29·963	30·083	30·114	50·2	41·6	SW	12	29·480	29·584	29·731	29·768	47·2	41·0	SSW
13	30·046	30·000	29·933	29·863	47·9	42·8	S	13	29·570	29·596	29·604	29·594	49·3	44·3	SSW
14	29·798	29·758	29·753	29·843	44·6	42·2	E	14	29·626	29·701	29·736	29·799	46·6	35·6	NW
15	29·941	30·059	29·983	29·871	46·3	37·9	SW	15	29·806	29·869	29·624	29·475	43·1	35·8	SE
16	29·840	29·879	29·824	29·797	49·9	44·0	SW	16	29·468	29·428	29·398	29·436	47·8	38·4	SW
17	29·695	29·619	29·464	29·446	51·1	44·2	SW	17	29·246	29·187	29·167	29·098	46·3	42·3	SW
18	29·440	29·502	29·604	29·753	49·0	41·0	W	18	29·166	29·278	29·382	29·554	45·1	38·9	WSW
19	29·864	29·931	29·835	29·694	48·9	37·3	SW	19	29·615	29·554	29·308	29·084	47·5	39·1	SSW
20	29·546	29·564	29·526	29·722	49·8	42·9	SW	20	28·908	28·977	29·192	29·417	45·8	41·0	WSW
21	29·875	29·951	29·855	29·808	48·1	40·1	SW	21	29·490	29·468	29·352	29·327	46·2	38·2	SW
22	29·669	29·573	29·401	29·478	47·1	37·8	SW	22	29·251	29·210	29·144	29·421	40·8	35·1	SW
23	29·573	29·812	29·931	30·107	39·9	30·6	N	23	29·603	29·814	29·929	29·946	35·4	29·0	WNW
24	30·176	30·193	30·056	29·964	44·9	26·2	SSW	24	29·790	29·622	29·470	29·447	47·9	32·0	S
25	29·965	29·875	29·726	29·528	48·2	44·9	SSW	25	29·522	29·502	29·310	29·278	47·1	35·1	WSW
26	29·442	29·698	29·846	29·880	45·4	37·8	W	26	29·335	29·407	29·407	29·234	41·9	31·1	SW
27	29·803	29·773	29·635	29·542	51·2	43·9	SW	27	29·142	29·030	29·021	29·069	47·9	35·2	WSW
28	29·580	29·693	29·676	29·788	46·8	35·8	W	28	29·080	29·044	29·276	29·619	38·4	32·6	SW
29	29·937	30·067	30·012	29·788	43·8	34·9	W	29	29·766	29·779	29·424	29·052	44·7	31·9	S
30	29·643	29·740	29·728	29·567	47·5	40·1	W	30	29·082	29·159	29·138	29·128	44·8	32·2	SW
31	29·339	29·288	29·394	29·433	45·1	34·7	WNW	31	29·102	29·145	29·231	29·409	36·0	31·6	SW

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1	29·695	29·882	29·896	29·827	49·2	33·4	W	1	29·495	29·562	29·338	29·424	45·3	29·3	SSW
2	29·936	30·043	30·016	30·010	52·6	47·4	SW	2	29·547	29·538	29·438	29·492	49·6	44·7	SW
3	29·961	30·019	30·196	30·381	50·5	38·6	WNW	3	29·548	29·720	29·985	30·115	47·0	38·8	WSW
4	30·437	30·456	30·382	30·370	48·9	34·8	SW	4	30·105	30·046	29·920	30·051	49·5	39·7	SSW
5	30·368	30·391	30·363	30·364	49·2	41·1	WSW	5	30·159	30·238	30·201	30·069	44·3	36·9	SSW
6	30·297	30·231	30·094	30·003	51·7	41·0	SW	6	29·772	29·530	29·362	29·322	50·9	39·0	SW
7	29·938	29·936	29·890	29·913	55·0	50·4	SW	7	29·279	29·327	29·250	29·509	52·4	39·6	SW
8	30·012	30·230	30·272	30·252	53·0	40·7	WNW	8	29·676	29·867	29·862	29·809	45·3	39·4	WSW
9	30·095	29·880	29·807	29·851	52·3	39·8	SW	9	29·588	29·444	29·424	29·344	45·3	38·5	SW
10	29·797	29·768	29·689	29·640	49·4	42·0	WSW	10	29·236	29·253	29·268	29·255	40·7	35·1	W
11	29·524	29·564	29·483	29·288	53·1	45·4	WSW	11	29·198	28·996	28·738	28·501	48·1	35·3	NE
12	29·339	29·546	29·615	29·675	49·8	37·7	W	12	28·604	29·122	29·278	29·430	43·5	32·7	W
13	29·737	29·978	30·071	30·105	44·1	34·1	NW	13	29·699	29·867	29·967	30·024	39·8	31·1	W
14	30·109	30·157	30·156	30·167	42·1	29·9	W	14	30·072	30·110	30·082	30·068	34·2	27·1	NE
15	30·145	30·139	30·087	30·096	48·1	36·9	W	15	30·020	29·997	29·950	29·961	35·6	30·7	ENE
16	30·043	30·047	30·040	30·087	47·3	39·2	WSW	16	29·885	29·890	29·883	29·914	41·6	35·0	ENE
17	30·111	30·131	30·046	30·039	41·2	37·9	ESE	17	29·938	30·004	30·074	30·186	40·9	34·8	NE
18	30·149	30·240	30·425	30·526	37·9	29·1	E	18	30·251	30·342	30·358	30·391	38·5	34·0	SSE
19	30·515	30·523	30·479	30·471	37·4	27·0	E	19	30·362	30·362	30·390	30·504	40·4	31·4	S
20	30·431	30·447	30·374	30·377	37·5	25·8	E	20	30·311	30·372	30·352	30·290	41·1	36·9	SSW
21	30·325	30·369	30·249	30·298	36·9	23·0	E	21	30·192	30·185	30·171	30·245	44·1	38·7	WSW
22	30·299	30·320	30·218	30·179	39·2	23·2	NE	22	30·271	30·254	30·079	29·891	45·4	33·9	WNW
23	30·080	30·066	29·821	29·657	44·0	28·0	SW	23	29·740	29·598	29·642	29·2·2	47·0	38·7	SSW
24	29·539	29·609	29·795	29·890	47·6	34·2	W	24	29·254	29·304	29·476	29·576	39·7	32·7	W
25	29·889	29·762	29·616	29·589	52·2	34·2	SW	25	29·458	29·057	29·069	29·110	49·0	32·9	SW
26	29·684	29·714	29·731	29·803	52·9	48·4	SW	26	29·264	29·273	29·341	29·194	49·4	37·1	SW
27	29·799	29·827	29·911	30·033	54·2	39·1	W	27	29·284	29·448	29·592	29·688	49·7	35·6	SW
28	29·961	29·873	29·901	30·072	47·3	36·5	W	28	29·525	29·569	29·642	29·618	41·9	35·5	SW

MARCH, 1894.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	29·995	29·906	29·805	29·791	48·7	37·6	SW	1	29·258	29·253	29·274	29·290	45·2	39·3	SW
2	29·925	30·063	30·094	30·197	50·5	36·9	W	2	29·334	29·555	29·780	29·910	45·8	36·2	WSW
3	30·194	30·201	30·116	30·084	49·1	29·5	SW	3	29·910	29·860	29·815	29·774	44·4	36·1	SW
4	30·020	30·037	29·987	30·149	50·2	34·6	W	4	29·606	29·678	29·955	30·112	45·3	35·4	NW
5	30·299	30·327	30·168	29·940	47·6	32·4	WSW	5	30·089	29·956	29·538	29·374	47·6	35·0	SSW
6	29·665	29·618	29·596	29·684	50·5	41·8	WNW	6	29·211	29·298	29·515	29·688	45·7	38·6	WNW
7	29·795	29·858	29·827	29·752	47·8	35·6	WSW	7	29·719	29·695	29·546	29·320	42·6	32·7	SSE
8	29·652	29·603	29·575	29·658	48·6	39·3	SW	8	29·119	29·315	29·332	29·331	45·5	37·4	SW
9	29·650	29·616	29·547	29·532	49·5	39·0	SW	9	29·242	29·155	29·059	29·194	48·4	38·7	SSW
10	29·572	29·670	29·692	29·711	53·2	44·3	WSW	10	29·235	29·312	29·328	29·125	43·4	34·6	SW
11	29·558	29·473	29·538	29·649	54·0	40·2	W	11	28·756	28·993	29·059	29·152	48·1	34·3	SW
12	29·640	29·667	29·601	29·411	50 9	39·9	W	12	29·156	29·176	29·160	29·096	42·6	34·0	SW
13	29·030	29·225	29·341	29·376	49·0	39·0	W	13	28·920	28·870	28·981	29·141	45·0	35·1	W
14	29·457	29·539	29·456	29·359	48·8	35·9	W	14	29·246	29·306	29·279	29·322	44·1	34·3	SW
15	29·246	29·411	29·528	29·673	48·9	37·0	N	15	29·364	29·442	29·510	29·630	43·6	31·9	WNW
16	29·742	29·828	29·876	30·014	47·7	32·5	N	16	29·716	29·835	29·905	30·008	45·3	30·7	W
17	30·097	30·206	30·200	30·267	46·4	29·8	N	17	30·064	30·122	30·162	30·133	47·7	31·3	W
18	30·265	30·308	30·246	30·293	51·5	30·7	NE	18	30·117	30·159	30·149	30·184	48·0	39·7	SW
19	30·286	30·319	30·259	30·271	51·9	29·1	E	19	30·174	30·230	30·220	30·258	50·4	45·1	W
20	30·244	30·258	30·221	30·250	53·2	42·9	NE	20	30·223	30·246	30·208	30·208	47·2	44·1	SW
21	30·199	30·236	30·201	30·272	52·9	39·9	E	21	30·171	30·206	30·190	30·254	53·3	42·1	SW
22	30·288	30·348	30·345	30·402	46·1	40·1	E	22	30·268	30·315	30·294	30·382	56·1	37·9	NE
23	30·409	30·458	30·397	30·410	52·4	40·1	ENE	23	30·394	30·448	30·416	30·444	58·7	35·9	NW
24	30·376	30·357	30·249	30·219	55·4	37·2	E	24	30·432	30·401	30·281	30·270	59·1	37·7	ESE
25	30·151	30·142	30·056	30·048	56·5	39·7	E	25	30·209	30·169	30·064	30·062	58·8	37·3	ENE
26	30·011	30·020	29·971	30·030	59·3	33·8	E	26	30·035	30·019	29·946	29·996	57·6	37·2	E
27	30·025	30·092	30·061	30·165	62·0	29·5	E	27	30·041	30·111	30·098	30·200	54·7	36·3	E
28	30·191	30·243	30·206	30·250	55·7	29·8	E	28	30·222	30·242	30·158	30·151	52·6	37·5	NE
29	30·235	30·229	30·105	30·100	58·1	40·3	E	29	30·102	30·074	29·992	29·974	60·1	35·8	SW
30	29·963	29·884	29·753	29·757	62·7	35·0	SE	30	29·894	29·826	29·696	29·665	60·7	37·0	SSW
31	29·700	29·741	29·777	29·890	63·0	45·1	SW	31	29·643	29·696	29·728	29·842	57·7	41·8	SSE

APRIL, 1894.

1	29·943	30·010	29·964	29·931	65·2	41·2	SW	1	29·891	29·968	29·948	29·959	56·1	41·9	S
2	29·935	29·907	29·831	29·835	63·0	39·0	ESE	2	29·915	29·891	29·833	29·846	55·2	38·7	E
3	29·815	29·829	29·802	29·894	65·1	37·4	SSE	3	29·842	29·879	29·874	29·941	48·4	40·9	E
4	29·961	30·060	30·064	30·134	58·9	41·3	ENE	4	29·983	30·089	30·119	30·203	47·4	39·8	E
5	30·131	30·127	30·045	30·063	58·9	39·5	ENE	5	30·208	30·242	30·197	30·234	52·9	40·8	NE
6	29·981	29·967	29·945	29·974	54·0	44·3	E	6	30·210	30·165	30·070	30·101	48·8	39·7	ENE
7	29·946	29·955	29·872	29·901	64·1	43·3	ENE	7	30·062	30·054	30·008	29·996	48·7	41·4	NE
8	29·885	29·888	29·821	29·871	70·2	46·1	S	8	29·925	29·906	29·846	29·833	48·9	40·5	E
9	29·910	29·980	29·984	30·036	63·2	44·1	SW	9	29·772	29·755	29·769	29·841	53·1	40·8	SSW
10	30·044	30·050	29·984	29·994	68·6	37·1	S	10	29·869	29·903	29·892	29·899	57·3	46·6	S
11	29·930	29·879	29·767	29·779	70·0	46·5	S	11	29·894	29·915	29·842	29·834	61·9	49·6	ENE
12	29·717	29·759	29·742	29·778	60·0	45·9	SW	12	29·788	29·767	29·752	29·840	56·8	43·7	ENE
13	29·766	29·784	29·748	29·775	59·3	42·6	WNW	13	29·732	29·834	29 790	29·770	46·4	41·1	ESE
14	29·704	29·703	29·694	29·732	54·1	41·7	S	14	29·798	29·614	29·510	29·515	50·1	35·6	ESE
15	29·746	29·730	29·666	29·593	60·1	48·6	S	15	29·622	29·616	29·520	29·530	56·2	41·9	SE
16	29·436	29·362	29·383	29·438	54·9	47·4	S	16	29·499	29·437	29·346	29·306	55·1	39·9	NE
17	29·466	29·489	29·483	29·536	57·9	43·9	S	17	29·277	29·351	29·422	29·523	50·7	44·4	NNE
18	29·553	29·645	29·701	29·831	60·6	44·4	ESE	18	29·593	29·736	29·834	29·984	54·5	44·9	N
19	29·889	30·013	30·060	30·133	49·1	43·5	NNE	19	30·044	30·102	30·096	30·135	56·9	43·4	NW
20	30·127	30·137	30·092	30·089	49·2	42·8	NNE	20	30·120	30·098	30·018	30·020	60·3	36·8	S
21	30·062	30·063	29·979	30·005	53·2	38·8	NE	21	30·002	29·980	29·919	29·934	59·9	38·6	S
22	29·948	29·909	29·771	29·714	53·5	33·5	E	22	29·890	29·839	29·729	29·719	55·8	39·3	E
23	29·602	29·585	29·584	29·626	56·9	40·9	ESE	23	29·647	29·610	29·575	29·566	47·6	42·1	E
24	29·645	29·668	29·673	29·705	57·0	43·3	S	24	29·508	29·448	29·399	29·441	53·8	42·0	SE
25	29·663	29·654	29·695	29·718	58·3	44·8	WSW	25	29·446	29·441	29·430	29·446	54·9	42·2	SSE
26	29·696	29·685	29·643	29·615	59·3	46·4	S	26	29·480	29·502	29·483	29·511	55·8	44·6	S
27	29·560	29·643	29·646	29·689	59·1	45·9	SW	27	29·521	29·549	29·602	29·709	54·4	43·5	E
28	29·738	29·860	29·963	30·092	56·1	42·6	N	28	29·741	29·955	29·965	30·000	60·9	41·7	N
29	30·106	30·107	30·015	30·014	63·0	37·9	NW	29	29·960	29·956	29·946	29·986	57·6	47·2	SW
30	29·985	30·035	30·085	30·231	57·0	44·5	W	30	30·073	30·208	30·252	30·363	58·3	46·8	WNW

MAY, 1894.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	30·242	30·288	30·260	30·203	54·0	40·2	N
2	30·238	30·197	30·085	30·005	53·6	35·8	WNW
3	29·878	29·822	29·774	29·790	59·9	47·7	NW
4	29·776	29·803	29·850	29·918	53·6	42·4	NW
5	29·906	29·921	29·843	29·820	58·9	39·6	W
6	29·775	29·758	29·738	29·788	58·5	46·7	SW
7	29·785	29·855	29·845	29·951	60·7	41·9	WNW
8	29·974	30·012	29·985	29·966	56·6	44·9	SW
9	29·884	29·802	29·768	29·766	56·9	44·1	SW
10	29·782	29·761	29·759	29·805	55·4	41·9	SW
11	29·826	29·833	29·747	29·704	58·2	40·4	SSW
12	29·776	29·945	30·010	30·090	57·2	45·1	N
13	30·084	30·080	30·021	30·003	60·1	41·1	NW
14	29·966	29·960	29·946	29·898	64·5	49·0	S
15	29·858	29·845	29·817	29·854	65·6	49·0	E
16	29·830	29·881	29·912	30·032	66·1	53·6	E
17	30·073	30·100	30·052	30·122	65·3	49·0	N
18	30·118	30·135	30·101	30·174	64·1	44·2	NE
19	30·174	30·184	30·097	30·061	50·7	41·8	NE
20	29·970	29·939	29·897	29·929	48·7	36·8	N
21	29·919	29·922	29·904	29·968	52·2	33·8	N
22	29·988	30·014	30·066	30·129	51·2	34·2	N
23	30·128	30·132	30·186	30·258	55·2	43·0	NE
24	30·258	30·246	30·184	30·210	63·9	45·0	NE
25	30·134	30·032	29·915	29·847	65·1	42·5	NNE
26	29·803	29·760	29·684	29·681	52·1	42·5	NNW
27	29·601	29·649	29·676	29·691	51·4	41·9	N
28	29·627	29·572	29·526	29·531	54·0	40·4	SSW
29	29·537	29·588	29·602	29·669	55·4	40·0	WSW
30	29·690	29·713	29·701	29·732	58·8	40·8	SW
31	29·735	29·747	29·769	29·844	58·7	40·7	WSW

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	30·372	30·352	30·288	30·242	57·1	40·1	W
2	30·110	29·979	29·827	29·690	51·3	43·9	SW
3	29·669	29·672	29·622	29·674	51·2	41·7	WNW
4	29·662	29·738	29·806	29·844	48·9	36·0	WNW
5	29·816	29·788	29·688	29·545	50·6	37·2	WSW
6	29·509	29·511	29·539	29·562	51·3	42·5	W
7	29·526	29·564	29·632	29·734	50·8	40·3	WSW
8	29·728	29·684	29·631	29·565	53·1	44·0	SW
9	29·605	29·601	29·519	29·486	54·3	43·1	SW
10	29·411	29·390	29·438	29·530	52·6	44·6	SSW
11	29·592	29·656	29·708	29·804	55·7	44·0	SW
12	29·886	29·962	30·029	30·090	54·4	39·1	WNW
13	30·072	30·027	29·947	29·917	55·6	38·7	E
14	29·844	29·854	29·885	29·909	50·3	42·9	E
15	29·946	30·018	30·006	30·068	53·3	46·4	ENE
16	30·072	30·147	30·215	30·289	48·4	44·0	E
17	30·292	30·343	30·324	30·359	51·4	41·1	E
18	30·321	30·319	30·326	30·381	54·1	41·7	E
19	30·377	30·344	30·243	30·180	46·1	40·1	NE
20	30·105	30·038	29·978	29·996	49·2	32·1	N
21	29·988	30·001	29·974	30·041	50·6	32·4	NE
22	30·065	30·099	30·129	30·222	53·9	33·1	SSW
23	30·297	30·359	30·378	30·437	58·5	36·3	E
24	30·446	30·426	30·327	30·300	62·1	37·5	ENE
25	30·228	30·138	29·995	30·015	60·4	42·8	NW
26	29·963	29·926	29·946	30·005	54·8	42·1	N
27	29·940	29·858	29·735	29·678	54·3	38·4	NW
28	29·594	29·584	29·547	29·561	51·3	42·9	NW
29	29·561	29·611	29·616	29·685	56·8	42·8	NE
30	29·666	29·661	29·609	29·633	53·9	40·0	E
31	29·626	29·654	29·676	29·733	55·1	41·2	SW

JUNE, 1894.

1	29·864	29·876	29·828	29·793	60·0	49·2	S	1	29·764	29·796	29·782	29·784	61·8	39·0	W
2	29·722	29·685	29·734	29·850	62·9	52·1	SW	2	29·718	29·681	29·694	29·803	58·0	44·9	ENE
3	29·902	29·972	29·951	29·954	64·4	50·5	S	3	29·871	29·846	29·950	29·982	54·2	47·7	E
4	29·867	29·756	29·699	29·782	66·0	52·9	ESE	4	29·938	29·898	29·828	29·786	53·1	45·7	E
5	29·784	29·791	29·755	29·729	63·2	52·5	SW	5	29·835	29·766	29·804	29·868	51·9	44·0	E
6	29·727	29·772	29·660	29·658	59·0	49·6	NE	6	29·898	29·897	29·826	29·829	59·3	39·1	SE
7	29·681	29·767	29·818	29·898	61·2	48·2	N	7	29·818	29·820	29·810	29·851	60·9	44·9	W
8	29·929	29·974	29·936	29·916	63·6	48·9	W	8	29·859	29·868	29·833	29·818	61·3	47·3	WSW
9	29·839	29·841	29·839	29·890	63·6	54·8	SW	9	29·784	29·823	29·848	29·877	56·8	50·2	ENE
10	29·886	29·850	29·742	29·688	62·3	52·4	WSW	10	29·806	29·678	29·578	29·600	55·4	49·2	SSW
11	29·717	29·731	29·708	29·705	59·8	48·1	WNW	11	29·627	29·624	29·612	29·704	59·6	45·3	WNW
12	29·755	29·881	29·913	29·888	60·2	45·1	NW	12	29·811	29·855	29·846	29·906	65·3	49·1	W
13	29·843	29·948	29·997	30·083	56·7	49·9	N	13	29·940	29·987	29·994	30·042	68·3	43·8	NW
14	30·095	30·126	30·082	30·120	70·5	48·0	NW	14	30·064	30·070	30·049	30·019	61·1	44·1	W
15	30·110	30·167	30·081	30·060	67·0	51·3	W	15	29·932	29·857	29·914	30·028	60·8	51·6	SW
16	30·080	30·112	30·075	30·064	67·7	53·7	NW	16	30·068	30·057	29·954	29·883	64·1	47·6	SW
17	29·997	29·955	29·876	29·856	64·9	50·2	SW	17	29·718	29·611	29·666	29·686	58·3	49·0	WSW
18	29·827	29·768	29·704	29·844	61·1	50·3	SW	18	29·661	29·685	29·754	29·890	58·7	44·2	SW
19	29·965	30·083	30·067	30·066	65·6	47·9	W	19	29·925	29·916	29·859	29·789	58·1	44·5	SW
20	30·000	29·983	29·985	30·036	63·3	54·6	SW	20	29·794	29·885	29·946	30·019	60·3	50·9	WNW
21	30·096	30·162	30·156	30·169	72·5	51·3	SSW	21	30·055	30·066	30·044	30·045	64·0	42·3	WSW
22	30·145	30·125	30·073	30·070	69·6	51·2	SW	22	29·982	29·889	29·873	29·936	62·0	51·9	SSW
23	30·031	29·980	29·909	29·876	68·1	58·4	SW	23	29·885	29·774	29·594	29·604	58·0	50·6	SW
24	29·861	29·938	30·027	30·136	64·6	54·7	WNW	24	29·686	29·794	29·885	29·967	57·1	47·3	W
25	30·154	30·179	30·161	30·291	72·6	50·2	WSW	25	29·961	30·025	30·103	30·184	56·6	49·6	ENE
26	30·225	30·248	30·259	30·264	69·8	56·3	NNE	26	30·245	30·282	30·296	30·317	68·1	54·1	W
27	30·260	30·264	30·199	30·237	69·9	53·0	NE	27	30·322	30·342	30·307	30·350	71·1	55·3	E
28	30·242	30·247	30·208	30·269	76·5	52·0	E	28	30·334	30·333	30·313	30·343	72·0	52·0	ENE
29	30·309	30·317	30·297	30·340	77·1	51·2	NE	29	30·374	30·384	30·341	30·376	75·2	55·4	E
30	30·349	30·350	30·300	30·291	78·6	53·1	E	30	30·410	30·401	30·334	30·329	80·7	51·7	N

JULY, 1894.

	KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·261	30·233	30·171	30·159	80·7	58·2	E	1	30·331	30·279	30·190	30·153	75·6	52·9	ENE
2	30·114	30·105	30·057	30·080	77·9	59·2	SW	2	30·112	30·025	29·986	29·994	66·4	56·0	NE
3	30·057	30·102	30·094	30·143	69·2	54·8	NW	3	30·003	30·040	30·050	30·070	63·4	50·7	W
4	30·145	30·160	30·139	30·160	74·5	51·3	W	4	30·042	30·040	30·018	30·014	62·2	50·6	SW
5	30·159	30·146	30·078	30·072	77·2	52·0	S	5	29·999	30·003	30·005	30·004	66·1	57·1	S
6	30·012	29·958	29·868	29·873	83·4	58·4	SSE	6	29·944	29·920	29·738	29·735	72·1	55·9	SSE
7	29·908	29·987	29·975	30·022	69·8	53·3	SW	7	29·737	29·765	29·785	29·818	63·4	53·0	SW
8	30·041	30·051	30·007	29·941	70·0	49·8	SW	8	29·8·6	29·843	29·858	29·822	59·1	47·9	SW
9	29·805	29·773	29·724	29·718	71·2	55·8	W	9	29·748	29·701	29·659	29·617	62·3	52·9	W
10	29·653	29·575	29·437	29·299	65·3	55·3	SSW	10	29·548	29·501	29·440	29·384	61·2	52·7	W
11	29·278	29·354	29·387	29·399	67·5	53·1	W	11	29·329	29·296	29·274	29·256	66·6	48·6	WSW
12	29·264	29·309	29·479	29·610	66·0	52·3	W	12	29·227	29·221	29·235	29·291	65·1	48·6	W
13	29·617	29·626	29·591	29·644	66·7	53·9	SSW	13	29·294	29·342	29·391	29·471	62·7	53·0	SW
14	29·651	29·639	29·640	29·712	67·4	48·7	S	14	29·504	29·569	29·603	29·660	62·6	51·9	SW
15	29·739	29·844	29·881	29·947	62·4	51·9	W	15	29·682	29·765	29·786	29·824	64·1	51·9	W
16	29·952	29·911	29·796	29·773	62·2	53·5	SW	16	29·748	29·598	29·498	29·487	62·3	48·4	E
17	29·776	29·780	29·760	29·771	66·2	56·9	W	17	29·481	29·492	29·498	29·469	58·2	53·0	SW
18	29·685	29·639	29·635	29·695	65·1	54·6	W	18	29·430	29·482	29·521	29·572	66·4	51·2	W
19	29·695	29·740	29·803	29·875	65·2	53·6	WNW	19	29·605	29·655	29·696	29·741	65·1	46·3	W
20	29·889	29·920	29·908	29·889	66·3	53·2	SW	20	29·748	29·750	29·721	29·768	65·1	48·3	SSW
21	29·890	29·794	29·775	29·829	70·4	55·6	NW	21	29·769	29·728	29·707	29·748	61·9	47·4	WSW
22	29·851	29·871	29·842	29·808	67·7	54·0	W	22	29·778	29·819	29·823	29·886	64·1	50·0	W
23	29·731	29·761	29·824	29·889	61·2	50·8	N	23	29·920	29·956	29·972	30·070	67·1	45·2	E
24	29·924	29·957	29·914	29·913	73·3	58·0	NE	24	30·128	30·159	30·174	30·188	65·9	50·3	E
25	29·900	29·947	29·923	29·927	73·2	55·8	S	25	30·100	30·030	29·976	29·930	60·5	54·7	E
26	29·891	29·885	29·882	29·920	70·3	56·0	S	26	29·890	29·898	29·871	29·915	66·1	56·9	E
27	29·935	29·950	29·937	30·008	74·9	54·4	SW	27	29·923	30·048	29·941	30·013	69·9	57·8	E
28	30·044	30·062	30·039	30·051	74·3	53·5	SE	28	30·035	30·063	30·054	30·103	69·0	56·4	ENE
29	29·986	29·992	29·901	29·854	69·1	60·3	ENE	29	30·097	30·100	30·063	30·094	71·9	53·9	ENE
30	29·868	29·937	29·975	30·000	67·8	58·5	N	30	30·056	30·036	29·984	29·967	73·2	50·5	E
31	29·989	29·984	29·943	29·955	72·7	55·5	SW	31	29·943	29·908	29·866	29·832	69·9	54·0	NE

AUGUST, 1894.

1	29·903	29·861	29·798	29·805	68·3	58·9	SW	1	29·730	29·643	29·598	29·589	64·7	57·0	SW
2	29·736	29·637	29·575	29·539	67·3	57·9	SW	2	29·554	29·482	29·426	29·342	61·3	53·9	WNW
3	29·536	29·573	29·622	29·695	67·8	53·3	W	3	29·376	29·416	29·459	29·541	64·1	53·9	W
4	29·729	29·759	29·749	29·736	67·4	54·3	SW	4	29·558	29·572	29·536	29·584	60·9	53·2	SW
5	29·807	29·898	29·885	29·883	68·5	57·8	SW	5	29·628	29·638	29·605	29·609	60·2	49·4	SW
6	29·803	29·764	29·730	29·782	67·8	57·6	NNW	6	29·594	29·590	29·609	29·662	63·0	49·7	SW
7	29·811	29·867	29·879	29·882	69·3	56·3	SW	7	29·679	29·698	29·652	29·558	61·4	50·1	SW
8	29·793	29·769	29·685	29·663	67·8	58·1	SW	8	29·494	29·498	29·462	29·495	63·9	54·2	SW
9	29·687	29·763	29·803	29·859	66·9	54·9	W	9	29·522	29·600	29·653	29·735	66·4	52·9	W
10	29·833	29·897	29·931	30·037	66·2	54·7	WNW	10	29·790	29·953	29·979	30·029	63·9	52·7	W
11	30·054	30·097	30·101	30·131	64·3	52·5	NW	11	30·003	30·004	29·979	29·970	60·1	50·0	W
12	30·103	30·083	29·972	29·901	66·0	55·2	SW	12	29·867	29·799	29·690	29·723	60·3	54·5	SW
13	29·840	29·926	29·936	29·969	66·9	58·2	NW	13	29·783	29·838	29·865	29·786	60·8	51·0	W
14	29·855	29·757	29·633	22·613	75·7	57·6	SW	14	29·542	29·401	29·261	29·172	69·8	50·2	WSW
15	29·558	29·552	29·544	29·582	66·1	55·1	SW	15	29·116	29·176	29·265	29·461	62·2	50·0	W
16	29·624	29·719	29·827	29·952	61·1	51·7	NW	16	29·592	29·711	*	29·924	60·1	49·7	W
17	30·025	30·071	30·066	30·080	60·7	46·7	WNW	17	29·942	29·946	29·977	30·035	61·4	47·0	W
18	30·060	30·076	30·052	30·068	64·1	52·4	NW	18	30·012	30·013	30·007	30·005	61·4	49·9	W
19	30·045	30·024	29·952	29·864	62·4	51·4	SW	19	29·910	29·792	29·710	29 725	60·1	50·7	SW
20	29·807	29·849	29·849	29·905	64·4	53·4	WNW	20	29·705	29·766	29·814	29·835	60·0	47·1	WNW
21	29·885	29·838	29·755	29·714	61·0	45·5	SW	21	29·786	29·732	29·679	29·701	56·1	45·0	WNW
22	29·738	29·803	29·834	29·887	69·5	52·0	WSW	22	29·703	29·764	29·809	29·878	63·8	45·5	SW
23	29·856	29·792	29·767	29·849	59·2	56·7	E	23	29·900	29·950	29·969	30·062	63·4	44·7	NE
24	29·908	30·030	30·061	30·108	63·9	56·1	N	24	30·100	30·164	30·168	30·265	62·1	46·3	NE
25	30·052	30·072	30·025	29·977	60·3	56·6	E	25	30·281	30·262	30·202	30·196	59·4	44·8	E
26	29·905	29·940	29·936	29·983	73·0	56·2	SW	26	30·189	30·060	30·018	30·050	53·9	46·2	ENE
27	29·971	30·010	30·057	30·117	64·6	52·9	N	27	30·059	30·102	30·119	30·169	60·8	46·3	E
28	30·158	30·203	30·172	30·188	68·2	52·9	NNW	28	30·174	30·180	30·176	30·173	59·3	45·1	W
29	30·193	30·219	30·208	30·235	65·2	51·9	N	29	30·164	30·198	30·196	30·193	58·7	49·9	W
30	30·235	30·247	30·169	30·157	71·6	50·1	N	30	30·179	30·185	30·160	30·142	60·7	53·3	W
31	30·114	30·104	30·035	30·069	73·3	49·7	N	31	30·088	30·069	30·042	30·070	61·3	52·0	W

* Light out.

SEPTEMBER, 1894.

	KEW.							GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·070	30·094	30·058	30·093	67·6	53·8	N	1	30·072	30·084	30·090	30·126	58·0	46·8	E
2	30·077	30·073	29·988	29·947	67·1	49·9	E	2	30·131	30·159	30·105	30·117	60·3	44·7	N
3	29·846	29·898	29·930	29·985	56·4	48·2	NE	3	30·088	30·082	30·023	30·059	58·1	49·0	W
4	29·997	30·047	30·026	30·075	60·9	45·3	N	4	30·068	30·096	30·085	30·120	59·1	46·7	NE
5	30·061	30·068	30·035	30·060	60·4	42·7	NW	5	30·120	30·155	30·138	30·191	59·2	49·3	N
6	30·044	30·078	30·064	30·123	57·5	42·2	N	6	30·186	30·198	30·157	30·138	57·3	44·6	S
7	30·105	30·102	30·035	30·018	59·3	44·2	W	7	30·062	30·034	29·971	29·972	58·1	43·0	W
8	29·881	29·835	29·887	29·976	58·9	48·4	N	8	29·960	30·002	30·063	30·181	58·8	41·1	N
9	30·026	30·131	30·195	30·314	61·8	50·6	N	9	30·259	30·366	30·384	30·420	60·3	40·1	SE
10	30·349	30·386	30·335	30·344	60·8	49·2	N	10	30·496	30·492	30·309	30·271	59·3	39·2	W
11	30·312	30·336	30·282	30·305	65·7	42·7	WNW	11	30·214	30·221	30·246	30·321	62·1	50·2	W
12	30·306	30·322	30·292	30·353	64·1	46·0	NNE	12	30·352	30·410	30·395	30·413	59·4	46·3	W
13	30·330	30·351	30·318	30·356	60·1	47·1	NE	13	30·414	30·421	30·361	30·391	64·4	44·9	W
14	30·332	30·356	30·321	30·351	62·4	51·9	NNE	14	30·382	30·391	30·368	30·386	60·8	47·0	W
15	30·337	30·359	30·323	30·338	60·3	51·4	NNW	15	30·386	30·414	30·390	30·407	62·8	48·1	W
16	30·306	30·320	30·284	30·308	59·8	52·9	NE	16	30·387	30·398	30·355	30·373	64·0	43·9	N
17	30·268	30·267	30·222	30·221	59·0	53·3	NE	17	30·360	30·369	30·328	30·374	61·7	45·9	ENE
18	30·157	30·139	30·074	30·081	64·0	51·6	ENE	18	30·344	30·335	30·266	30·260	56·3	50·3	E
19	30·057	30·087	30·057	30·086	66·0	51·3	E	19	30·209	30·202	30·179	30·186	56·0	50·1	ENE
20	30·069	30·079	30·021	30·035	61·1	52·3	NNE	20	30·170	30·178	30·136	30·135	57·3	51·0	ENE
21	29·998	29·988	29·941	29·925	57·0	54·1	NE	21	30·087	30·068	30·024	30·023	57·7	46·8	E
22	29·872	29·862	29·825	29·798	56·3	51·1	ENE	22	29·986	29·974	29·929	29·915	56·9	48·0	ENE
23	29·733	29·739	29·724	29·756	62·9	55·2	E	23	29·873	29·884	29·867	29·901	54·2	48·6	ENE
24	29·743	29·775	29·768	29·775	62·1	55·0	NE	24	29·908	29·931	29·921	29·936	56·4	44·5	E
25	29·673	29·634	29·572	29·606	59·7	55·8	E	25	29·890	29·876	29·803	29·822	57·7	45·9	NE
26	29·628	29·767	29·876	29·985	56·3	47·3	N	26	29·846	29·821	29·948	30·049	56·1	47·1	W
27	30·053	30·154	30·193	30·283	58·0	41·0	N	27	30·130	30·207	30·237	30·344	54·3	37·0	S
28	30·290	30·299	30·256	30·289	54·6	36·0	NNE	28	30·360	30·396	30·387	30·410	52·7	35·9	E
29	30·277	30·293	30·277	30·361	56·8	37·5	N	29	30·402	30·447	30·460	30·506	54·5	44·0	NE
30	30·377	30·422	30·429	30·463	58·0	43·4	NNE	30	30·504	30·530	30·509	30·510	50·8	43·8	E

OCTOBER, 1894.

1	30·438	30·479	30·433	30·450	57·3	42·6	ENE	1	30·466	30·460	30·436	30·427	54·5	43·3	S
2	30·410	30·425	30·339	30·323	57·6	49·5	NE	2	30·428	30·424	30·374	30·374	56·4	40·8	SW
3	30·256	30·229	30·181	30·197	57·1	50·1	NE	3	30·340	30·330	30·277	30·300	55·2	39·6	W
4	30·165	30·108	30·012	30·014	57·9	48·9	N	4	30·298	30·314	30·269	30·242	52·7	34·3	SW
5	29·989	30·011	29·980	30·000	57·2	51·3	N	5	30·200	30·199	30·162	30·178	53·1	48·7	E
6	29·940	29·907	29·878	29·916	57·1	50·4	NE	6	30·121	30·106	30·054	30·048	53·0	47·6	E
7	29·912	29·963	29·975	30·027	58·2	45·5	NE	7	30·016	30·040	30·027	30·054	54·9	48·1	E
8	30·038	30·076	30·059	30·103	53·0	42·1	NE	8	30·046	30·066	30·024	30·052	57·3	49·3	ENE
9	30·133	30·170	30·174	30·197	51·1	47·2	NE	9	30·043	30·037	29·986	29·930	57·3	47·9	SSW
10	30·160	30·141	30·119	30·144	59·0	50·2	S	10	29·924	30·009	30·049	30·130	59·6	47·2	W
11	30·154	30·215	30·214	30·266	61·7	55·9	N	11	30·158	30·219	30·206	30·240	55·0	39·4	N
12	30·270	30·305	30·260	30·273	61·0	45·6	E	12	30·202	30·198	30·176	30·174	61·0	47·7	SW
13	30·221	30·205	30·085	30·035	60·8	45·1	E	13	30·125	30·118	30·145	30·151	59·4	49·0	WSW
14	29·946	30·001	30·005	30·035	55·9	40·9	N	14	30·182	30·236	30·239	30·281	50·1	40·7	NE
15	30·043	30·087	30·077	30·115	51·0	39·1	NNW	15	30·274	30·314	30·284	30·345	49·6	40·1	N
16	30·109	30·122	30·105	30·153	50·2	36·9	NNW	16	30·278	30·283	30·241	30·222	49·9	32·8	WNW
17	30·123	30·096	29·998	29·949	50·7	32·6	NNW	17	30·151	30·061	29·969	29·910	49·3	38·5	WSW
18	29·841	29·777	29·673	29·642	48·2	39·5	NNW	18	29·861	29·861	29·800	29·792	44·7	37·1	E
19	29·615	29·640	29·666	29·660	48·8	39·8	NNE	19	29·758	29·795	29·774	29·798	41·9	29·7	NE
20	29·521	29·475	29·459	29·440	47·1	42·4	NNE	20	29·748	29·708	29·709	29·740	43·8	36·4	ENE
21	29·467	29·474	29·634	29·780	50·0	35·2	SW	21	29·693	29 707	29·764	29·851	46·2	34·8	E
22	29·785	29·779	29·782	29·873	48·7	33·8	NE	22	29·814	29·856	29·844	29·919	46·6	28·9	W
23	29·916	29·962	29·912	29·798	55·7	40·8	E	23	29·966	29·974	29·838	29·617	44·6	28·9	ENE
24	29·588	29·592	29·669	29·785	58·2	52·1	S	24	29·411	29·164	28·816	28·652	55·8	38·6	E
25	29·172	29·150	29·076	29·184	57·9	51·0	SW	25	28·652	28·696	28·767	28·868	52·4	47·5	W
26	29·356	29·516	29·404	29·244	59·2	50·6	S	26	29·317	29·491	29·399	29·271	47·8	38·7	ENE
27	29·196	29·249	29·295	29·431	56·1	49·7	SW	27	29·218	29·296	29·391	29·564	46·3	38·9	NE
28	29·480	29·635	29·689	29·639	55·4	47·2	SW	28	29·526	29·550	29·502	29·462	46·1	36·9	E
29	29·549	29·644	29·643	29·690	55·6	45·8	SW	29	29·272	29·308	29·314	29·490	47·6	40·3	SSW
30	29·714	29·752	29·821	29·885	52·2	48·2	SW	30	29·499	29 628	29·719	29·855	48·7	39 7	W
31	29·935	30·023	30·035	30·048	59·9	50·1	S	31	29·848	29·801	29·692	29·606	56·6	36·3	ENE

NOVEMBER, 1894.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·013	29·995	29·905	29·819	61·9	54·6	S	1	29·553	29·592	29·513	29·495	57·6	52·1	S
2	29·783	29·814	29·827	29·842	59·2	55·1	S	2	29·402	29·465	29·561	29·637	57·2	50·1	SW
3	29·791	29·749	29·714	29·726	61·0	53·1	S	3	29·582	29·482	29·396	29·367	55·8	49·5	SE
4	29·763	29·969	29·951	29·966	57·7	50·7	SW	4	29·435	29·591	29·622	29·536	51·0	47·2	SW
5	29·916	29·909	29·910	30·046	59·3	46·8	SSW	5	29·459	29·489	29·693	29·809	53·1	46·3	W
6	30·110	30·169	30·114	30·075	55·1	38·0	W	6	29·841	29·912	29·856	29·762	51·9	47·1	SW
7	29·960	29·841	29·589	29·403	57·0	39·2	S	7	29·589	29·438	29·299	29·279	52·1	45·1	S
8	29·505	29·625	29·677	29·722	51·1	42·0	W	8	29·294	29·380	29·377	29·486	47·8	41·3	WSW
9	29·715	29·689	29·594	29·570	52·7	41·7	S	9	29·512	29·424	29·330	29·367	51·1	45·1	S
10	29·544	29·559	29·498	29·415	55·1	44·1	W	10	29·308	29·300	29·242	29·201	48·1	41·9	SW
11	29·365	29·428	29·479	29·272	50·3	41·7	WSW	11	29·151	29·172	29·086	29·039	46·3	40·5	SW
12	29·201	29·111	28·869	29·020	54·5	42·8	S	12	28·980	29·019	29·103	29·252	46·8	42·4	WNW
13	29·439	29·712	29·752	29·593	49·1	42·7	W	13	29·410	29·492	29·286	28·870	46·2	36·9	SW
14	29·340	29·136	28·931	29·199	52·6	44·4	S	14	28·788	28·816	28·809	28·890	48·9	40·4	SSW
15	29·211	29·294	29·470	29·636	49·1	42·7	SW	15	28·974	29·074	29·162	29·280	44·9	38·3	SW
16	29·736	29·867	29·936	30·022	51·9	42·1	S	16	29·397	29·652	29·657	29·712	47·0	39·1	SSW
17	30·063	30·145	30·143	30·114	52·7	43·4	S	17	29·694	29·727	29·809	29·905	53·1	42·2	S
18	30·051	30·120	30·141	30·194	51·4	38·1	SSW	18	29·969	29·986	29·946	30·016	51·2	41·2	SE
19	30·192	30·226	30·243	30·279	52·9	35·7	S	19	30·028	30·054	30·006	29·932	49·6	36·3	S
20	30·253	30·204	30·152	30·178	53·3	37·9	S	20	29·842	29·744	29·926	30·055	51·3	40·2	WSW
21	30·323	30·439	30·433	30·428	47·1	42·7	NW	21	30·144	30·191	30·134	30·061	46·1	39·9	SSW
22	30·372	30·345	30·300	30·309	49·7	30·3	S	22	30·000	29·976	29·990	30·130	52·6	44·7	SSW
23	30·280	30·304	30·269	30·288	40·3	31·7	S	23	30·177	30·251	30·292	30·390	45·5	38·8	SW
24	30·288	30·319	30·287	30·304	49·2	35·3	NE	24	30·432	30·470	30·448	30·438	44·4	33·1	E
25	30·302	30·329	30·320	30·327	47·1	39·7	ENE	25	30·420	30·424	30·401	30·413	47·3	40·6	E
26	30·306	30·329	30·301	30·306	41·7	39·3	NNE	26	30·390	30·424	30·422	30·470	42·4	33·0	E
27	30·302	30·343	30·314	30·321	43·6	40·9	NE	27	30·454	30·451	30·361	30·315	41·9	29·3	E
28	30·242	30·363	30·340	30·351	42·9	33·9	NW	28	30·290	30·282	30·218	30·178	49·3	41·3	SW
29	30·292	30·281	30·243	30·292	48·3	34·0	NW	29	30·116	30·148	30·270	30·376	50·4	42·4	W
30	30·374	30·470	30·455	30·482	45·3	36·3	NNW	30	30·431	30·490	30·480	30·463	47·0	40·0	SW

DECEMBER, 1894.

1	30·468	30·494	30·434	30·438	39·6	28·6	N	1	30·438	30·448	30·410	30·401	44·9	39·8	W
2	30·426	30·419	30·304	29·244	44·0	31·5	N	2	30·358	30·338	...	30·213	43·6	35·8	SW
3	30·132	30·067	29·918	29·843	46·1	37·5	ENE	3	30·129	30·084	30·009	29·945	37·1	31·4	NE
4	29·736	29·722	29·690	29·721	39·0	32·9	E	4	29·868	29·844	29·789	29·788	40·7	31·5	E
5	29·761	29·842	29·871	29·944	41·5	38·5	NW	5	29·819	29·886	29·895	29·910	41·7	38·6	NE
6	29·977	30·015	29·986	29·955	39·2	31·2	NW	6	29·882	29·869	29·822	29·802	43·0	38·2	SW
7	29·859	29·848	29·771	29·724	43·1	34·1	SW	7	29·710	29·600	29·492	29·571	45·5	40·8	SE
8	29·723	29·864	29·987	30·085	47·0	32·5	NW	8	29·719	29·934	30·004	30·053	43·2	33·0	W
9	30·104	30·127	30·053	30·052	43·9	31·2	SE	9	30·010	29·984	29·867	29·681	43·4	32·9	E
10	30·048	30·085	30·100	30·136	47·6	43·2	S	10	29·676	29·758	29·796	29·877	51·1	41·7	S
11	30·123	30·138	30·073	30·025	48·1	41·2	S	11	29·869	29·801	29·807	29·830	51·1	43·6	S
12	29·966	30·058	30·151	30·195	50·6	41·9	W	12	29·767	29·841	29·788	29·752	50·5	38·1	SSW
13	30·155	30·166	30·121	30·116	50·8	43·8	SSW	13	29·655	29·563	29·542	29·679	54·1	50·0	SSW
14	30·116	30·127	30·021	29·824	51·6	47·1	SW	14	29·834	29·926	29·872	29·690	50·5	44·2	SW
15	29·850	29·975	30·104	30·202	48·2	39·3	W	15	29·583	29·749	29·922	29·910	46·4	37·9	W
16	30·063	29·960	30·103	30·214	51·1	38·5	WNW	16	29·849	30·052	30·130	30·125	42·1	34·4	NNW
17	30·191	30·104	29·959	29·888	50·1	37·8	S	17	29·924	29·719	29·684	29·556	46·7	32·3	NW
18	29·693	29·473	29·532	29·476	51·3	41·8	W	18	29·190	29·123	29·102	29·166	46·4	37·5	WSW
19	29·452	29·480	29·559	29·704	46·0	40·7	W	19	29·178	29·340	29·552	29·781	44·9	33·8	W
20	29·830	29·973	30·058	30·157	44·3	38·3	NW	20	29·946	30·102	30·112	30·041	41·1	36·5	WSW
21	30·158	30·125	29·962	29·788	50·0	32·3	SW	21	29·854	29·851	29·691	29·152	49·5	39·1	SW
22	29·439	29·399	29·601	29·939	50·3	40·7	W	22	28·270	28·738	29·522	29·811	50·6	37·6	WNW
23	30·120	30·224	30·189	30·121	45·9	36·4	SW	23	29·887	29·966	29·906	29·893	44·9	38·1	SW
24	30·063	30·106	30·163	30·268	49·0	45·7	WSW	24	29·937	30·013	30·087	30·220	45·1	42·3	ENE
25	30·348	30·459	30·506	30·547	47·7	44·3	WSW	25	30·284	30·358	30·377	30·402	50·2	42·7	SW
26	30·529	30·520	30·464	30·494	47·3	43·1	W	26	30·318	30·398	30·465	30·528	49·1	39·1	WNW
27	30·538	30·605	30·602	30·633	43·9	34·6	NW	27	30·524	30·586	30·622	30·588	43·9	37·0	W
28	30·586	30·481	30·142	29·751	45·1	32·0	SW	28	30·384	30·016	29·497	29·378	48·2	34·3	SW
29	29·496	29·374	29·346	29·375	46·7	36·3	W	29	28·986	29·041	29·184	29·247	39·1	32·3	WNW
30	29·319	29·333	29·373	29·488	38·1	32·2	NW	30	29·284	29·451	29·594	29·620	36·5	28·1	NE
31	29·540	29·640	29·687	29·767	35·7	27·2	NW	31	29·755	29·856	29·912	29·982	34·9	28·5	NW

THE NORTH OF ENGLAND INSTITUTE

OF

Mining and Mechanical Engineers.

ANNUAL REPORT OF THE COUNCIL

AND

ACCOUNTS FOR THE YEAR 1894-95;

LIST OF

COUNCIL, OFFICERS, AND MEMBERS,

FOR THE YEAR 1895-96;

AND

THE CHARTER AND BYE-LAWS.

1894-95.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE.
PRINTED BY ANDREW REID & CO., LTD., LONDON AND NEWCASTLE-UPON-TYNE.

1895.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL, 1894-95.

The following table shows the numbers of members of various classes during a few recent years:—

	August 1st.		
	1893.	1894	1895.
Honorary Members...	25	26	26
Members	565	624	717
Associate Members	47	53	67
Associates	47	68	67
Students	34	20	36
Subscribing Collieries, etc.	22	22	23
Totals	740	813	936

The steady increase of the membership is a matter of congratulation. The members are, however, desired, at all times, to promote its claims and advantages and to extend the membership, which is still below the figures of a few years ago, viz.:—Honorary Members, 23; Members, 792; Students, 142; and Subscribing Collieries, etc., 14; a total of 971 of all classes.

The initiation of the class of Associates, consisting of persons occupying subordinate positions in engineering, has proved very successful, and has materially increased the roll of members.

The revision of the composition payable in lieu of the annual subscription has been approved, as shown by the number of members who have so compounded. The Council will invest the amounts so received, as suitable investments are suggested to them.

The Council regret that no papers have been received from Students and Associates during the course of the year.

The additions to the library by donations, exchange, purchase, etc., have been:—

Bound volumes	248
Pamphlets, reports, etc.	314
A total of	562 titles.

And it is probable that the library now contains 6,914 volumes, and 1,171 unbound pamphlets. A card catalogue is now being prepared, and should render the books more readily available to members.

The library (including the books and weekly engineering papers) is available to members in the vicinity, from 10 a.m. to 5 p.m. daily, and those residing at a distance may make use of the books by communication with the Secretary.

It is a matter of regret that some of the files of publications have been rendered incomplete by the neglect of members to return borrowed books to the library, and it is earnestly desired that members will return the missing volumes.

The library could be rendered more valuable, if members would present volumes, etc., which they can spare from their own libraries. Members would also render a real service to the profession by bequeathing books, reports, plans, etc., to the library, where they would be preserved, be available for reference, and maintain the memory of the donor.

The Wood Memorial Hall, Lecture Theatre, etc., have been kept in good repair.

The reservation of a reading-room has been under consideration, and the Council trust that satisfactory arrangements to that effect will be shortly completed.

An arrangement has been made with the Literary and Philosophical Society of Newcastle-upon-Tyne, whose premises are connected with the library of the Institute, by which the door between the libraries of the two societies will be opened daily, and the members of either society are permitted (on producing a members pass) to refer to the books in the library of the other society.

Five volumes of the *Sinkings and Borings* (A to T) have been issued, and the remaining volumes will be published at early dates.

The prices of the *Transactions* and other publications of the Institute have been recently reduced, and members are recommended to complete their sets before the stock is exhausted.

Arrangements are being made in order that papers of interest to Indian and Colonial members may be locally read and discussed, and it is desired that the members will endeavour to ensure the success of such local meetings.

The Explosives Committee have continued their investigations as to the merits of the various flameless explosives at their weekly meetings. The first portion of their *Report* has been issued, and they anticipate being able to issue the second portion of their *Report* before the end of

the year. The Council have offered the use of the entire plant for testing explosives for use in mines to the Secretary of State for the Home Department.

The report of the Committee on Mechanical Ventilators is approaching completion, and will be issued during the current year to the members.

Mr. J. H. Merivale has been reappointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science at Ipswich in September next.

Mr. John Daglish has been reappointed on behalf of this Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane has been appointed as the representative of the Institute on the Science and Art Committee, and Mr. J. H. Merivale on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now completed its sixth year, during which general meetings have been held at Newcastle-upon-Tyne on September 5th, 6th, and 7th, 1894; at Birmingham on February 12th and 13th, 1895; and at London on May 30th and 31st and June 1st, 1895. The meeting held in this district was well attended, and the best thanks of the Institute are due to the Committee who made the arrangements, and to all those who by their services contributed to the holding of that successful meeting.

Prizes of books have been awarded to the writers of the following papers communicated to the members during the year 1893-94:—

"A Contribution to our Knowledge of Coal-dust. Part II." By Dr. P. Phillips Bedson.

"A Contribution to our Knowledge of Coal-dust. Part III." By Dr. P. Phillips Bedson and Mr. W. McConnell, Jun.

"The Combustion of Oxygen and Coal-dust in Mines." By Mr. W. C. Blackett.

"History and Description of the Greenside Silver Lead Mine, Patterdale." By Mr. W. H. Borlase.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

"The Ghorband Lead-mines, Afghanistan." By Mr. A. L. Collins.

"Note on the Antimony Deposit of El Altar, Sonora, Mexico." By Mr. Edward Halse.

"Note on the Occurrence of Mercury at Quindiú, Tolima, U.S. Colombia." By Mr. Edward Halse.

"Mining Explosives: Their Definition as Authorized under the Explosives Act, 1875." By Mr. A. C. Kayll.

"Miss-fires." By Mr. J. D. Kendall.

"Singareni Coal-field, Hyderabad, India." By Mr. J. P. Kirkup.

"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.
"Historical Sketch of the Whitehaven Collieries." By Mr. R. W. Moore.
"Magnetic Declination and its Variations." By Prof. H. Stroud.
"Minerals and Mining in Tasmania." By Mr. A. P. Wilson.

The papers communicated to the members during the year have been as follows :—

"The Brunsviga Calculating-machine." *Anon.*
"Coal-mines Regulation Bill, 1895." By Mr. M. Walton Brown.
"The Brunck Coke-oven and System for the Recovery of Bye-products." By Dr. R. Brunck.
"Sinking with Rock-drills." By Mr. Frank Coulson.
"The Semet-Solvay Coke-oven." By Mr. John H. Darby.
"Presidential Address." By Mr. T. Douglas.
"The Effect of an Obstruction in the Air-way of a Mine." By Mr. T. L. Elwen.
"Magnetic Declination in Mines." By Mr. James Henderson.
"Report of the Proceedings of the Flameless Explosives Committee. Part I.—Air and Combustible Gases." By Mr. A. C. Kayll.
"The Working of Hæmatite in the Whitehaven District." By Mr. J. M. Main.
"The Mining of the Softer Ores of Furness." By Mr. H. Mellon.
"Improvements in Brick-kilns." By Mr. R. W. Moore.
"The Extension of the West Cumberland Coal-field, Southward and Northward under the St. Bees Sandstone." By Mr. R. Russell.
"Electric Transmission of Power." By Mr. Alexander Siemens.
"Saving of Life from After-damp, Smoke, or Fumes in Mines." By Mr. Simon Tate.
"Engineering Heliography, or the Sun-print Copying of Engineering Drawings." By. Mr. B. H. Thwaite.
"Experiments with Explosives." By Mr. Winkhaus.
"British Guiana Gold-fields." By Mr. E. P. Wood.
"The Murton Coal-washer." By Mr. W. O. Wood.

In conclusion, the Council desire to impress upon the members that the success of the Institute in the future is entirely dependent upon a continued increase of the membership, so as to meet the considerable expenses incurred by its connexion with The Federated Institution of Mining Engineers.

REPORT OF THE FINANCE COMMITTEE.

The total income for the year amounted to £2,232 15s. 8d. ; deducting the sum of £131 2s. 0d., subscriptions of new life members, and £97 13s. 0d., subscriptions paid in advance, leaves £2,004 0s. 8d. as the ordinary income for the year. The ordinary income for the previous year, arrived at in the same manner, was £1,841 10s. 7d., showing an increase during this year of £162 10s. 0d.

The amount of subscriptions now in arrear, excluding the current year, is £71 8s. 0d.

The total expenditure amounted to £2,010 18s. 1d., an increase of £101 1s. 5d. The principal items contributing to this increase are :— Contributions to The Federated Institution of Mining Engineers, owing to the increased number of members, £39 11s. 5d. : postages, £10 12s. 2d. ; printing (including the *Report* of the Proceedings of the Flameless Explosives Committee), £45 12s. 9d. ; preparation of library card catalogue, £40 0s. 0d. ; law charges, £10 3s. 8d. ; and expenses of the meeting of The Federated Institution of Mining Engineers in this district, £44 9s. 1d. There is a decrease of £43 11s. 0d. in the expenses of the Flameless Explosives Committee : and £27 15s. 9d. in the cost of furnishing.

The Council having reduced the price to members of certain volumes of the *Transactions*, a reduction has been made in the value shown in the balance sheet.

August 3rd, 1895.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
July 21st, 1894.		
To Balance at Bankers	457 10 0	
„ „ in Treasurer's hands	84 12 3	
„ Outstanding Amounts for Authors' Excerpts	10 16 11	
July 21st, 1895.		552 19 2
To Dividend of 7½ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for the year ending June, 1895	201 0 0	
„ Interest on Investments with the River Tyne Commissioners	53 3 8	
		254 3 8
To SUBSCRIPTIONS FOR 1894-95 AS FOLLOWS:—		
508 Members ... ... @ £2 2s.	1,066 16 0	
1 Member ... ... @ £1 1s.	1 1 0	
37 Associate Members ... ... @ £2 2s.	77 14 0	
56 Associates ... ... @ £1 1s.	58 16 0	
18 Students ... ... @ £1 1s.	18 18 0	
97 New Members ... ... @ £2 2s.	203 14 0	
6 New Members (Life Compositions)	131 2 0	
19 New Associate Members ... ... @ £2 2s.	39 18 0	
12 New Associates ... ... @ £1 1s.	12 12 0	
22 New Students ... ... @ £1 1s.	23 2 0	
	1,633 13 0	
To SUBSCRIBING COLLIERIES, VIZ.:—		
3 @ £10 10s.	31 10 0	
3 @ £6 6s.	18 18 0	
5 @ £4 4s.	21 0 0	
10 @ £2 2s.	21 0 0	
1 New Subscriber @ £2 2s.	2 2 0	
	94 10 0	
To Donations	4 4 0	
	1,732 7 0	
Less—Subscriptions for current year paid in advance at the end of last year...	56 14 0	
	1,675 13 0	
To Arrears received	139 13 0	
	1,815 6 0	
„ Subscriptions paid in advance during current year ...	97 13 0	
		1,912 19 0
„ Sale of Publications		65 13 0
		£2,785 14 10

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.
JULY 31ST, 1895.

July 21st, 1895.	£	s.	d.	£	s.	d.
By Printing and Stationery				205	15	4
„ Books for Library	48	13	0			
„ Prizes for Papers	25	4	0			
„ Incidental Expenses	63	2	9			
„ Postages	67	17	7			
„ Sundry Accounts	7	8	4			
„ Travelling Expenses	14	12	6			
„ Salaries	150	0	0			
„ Clerks' Wages	147	2	8			
„ Reporter's Salary	16	16	0			
„ Rent	94	13	10			
„ Rates and Taxes	22	8	3			
„ Insurance	12	8	4			
„ Furnishing, Repairs, etc.	80	3	6			
„ Coals, Gas, Electric Light, and Water	39	15	3			
„ Library Card Catalogue	40	0	0			
„ Law Charges	10	3	8			
„ Printing and Stationery	0	8	0			
„ Translation of Papers	4	10	0			
„ Newcastle Meeting of The Federated Institution of Mining Engineers	44	9	1			
				889	16	9
„ Fan Committee	0	11	0			
„ Explosives Committee	38	5	1			
„ British Association Meeting—Delegate's Expenses ...	5	0	0			
				43	16	1
By The Federated Institution of Mining Engineers—Subscriptions	879	14	10			
Less—Amounts paid by Authors for Excerpts ...	8	4	11			
				871	9	11
				2,010	18	1
By Balance at Bankers	685	7	10			
„ „ in Treasurer's hands	84	12	3			
„ Outstanding Amounts for Authors' Excerpts	4	16	8			
				774	16	9
				£2,785	14	10

I have examined the above account with the Books and Vouchers relating thereto, and certify that, in my opinion, it is correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 2nd, 1895.

DR. THE TREASURER IN ACCOUNT

			£ s. d.	£ s. d.
To 624 Members, 30 of whom are Life Members.				
594	594	@ £2 2s.		1,247 8 0
To 53 Associate Members, 5 of whom are Life Members.				
48	48	@ £2 2s.		100 16 0
To 68 Associates		@ £1 1s.		71 8 0
To 20 Students, 1 of whom transferred to List of Members.				
19	19	@ £1 1s.		19 19 0
To 22 Subscribing Collieries				96 12 0
To 97 New Members		@ £2 2s.		203 14 0
To 6 New Members (Compositions)				131 2 0
To 19 New Associate Members @ £2 2s.				39 18 0
To 12 New Associates		@ £1 1s.		12 12 0
To 22 New Students		@ £1 1s.		23 2 0
To 1 New Subscriber				2 2 0
To Donations				4 4 0
				1,952 17 0
To Arrears, as per Balance Sheet 1893-94			192 3 0	
Add—Arrears considered irrecoverable, but since paid ...			18 18 0	
				211 1 0
				2,163 18 0
To Subscriptions Paid in Advance				97 13 0
				£2,261 11 0

WITH SUBSCRIPTIONS, 1894-95. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 508 Members. paid	@ £2 2s.	1,066 16 0	.....
By 1 „ paid	@ £1 1s.	.....	1 1 0
By 85 „ unpaid	@ £2 2s.	.....	178 10 0
594			
By 37 Associate Members, paid	@ £2 2s.	77 14 0	.....
By 11 „ „ unpaid	@ £2 2s.	.....	23 2 0
48			
By 56 Associates, paid	@ £1 1s.	58 16 0	.....
By 11 „ unpaid	@ £1 1s.	.....	11 11 0
By 1 „ dead		.....	1 1 0
68			
By 18 Students. paid	@ £1 1s.	18 18 0	.....
By 1 „ unpaid	@ £1 1s.	.....	1 1 0
19			
By 21 Subscribing Collieries, paid		92 8 0	.....
By 1 „ „ unpaid		.....	4 4 0
22			
By 97 New Members, paid	@ £2 2s.	203 14 0	.....
By 6 New Members (Life Compositions), paid		131 2 0	.....
By 19 New Associate Members, paid ...	@ £2 2s.	39 18 0	.....
By 12 New Associates, paid	@ £1 1s.	12 12 0	.....
By 22 New Students, paid	@ £1 1s.	23 2 0	.....
By 1 New Subscriber		2 2 0	.....
By Donations		4 4 0	.....
		1,732 7 0	220 10 0
By Arrears		139 13 0	71 8 0
By Subscriptions paid in advance		97 13 0	.....
		1,969 13 0	291 18 0
			1,969 13 0
			£2,261 11 0

Liabilities.	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	97	13	0			
„ carried over from previous year	2	2	0			
				99	15	0
Capital				9,159	17	11
				£9,259	12	11

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Bonds have been produced to me.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
August 2nd, 1895

Assets.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	685	7	10			
„ in Treasurer's hands	84	12	3			
Outstanding amounts for Authors' Excerpts ...	4	16	8			
				774	16	9
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd.	.....			2,680	0	0
Invested with River Tyne Commissioners ...	.....			1,500	0	0
Arrears of Subscriptions	.. ...			291	18	0
Value of 499 Bound Volumes of Transactions, @ 7s. 6d.	187	2	6			
„ 4,396 Sewn do., @ 5s.	1,099	0	0			
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AUGUST 3, 1895.

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* Honorary Members during term of office only.

	Date of Election.
1 The Right Honourable the EARL of RAVENSWORTH, Ravensworth Castle, Gateshead-upon-Tyne	Nov. 3, 1877
2*J. B. ATKINSON, Esq., H.M. Inspector of Mines, Glasgow ...	Aug. 4, 1888
3*W. N. ATKINSON, Esq., H.M. Inspector of Mines, Newcastle, Staffordshire	Aug. 4, 1888
4*W. BEATTIE-SCOTT, Esq., H.M. Inspector of Mines, Great Barr, near Birmingham	Dec. 10, 1887
5*Prof. P. PHILLIPS BEDSON, Durham College of Science, Newcastle-upon-Tyne	Feb. 10, 1883
6*THOMAS BELL, Esq., H.M. Inspector of Mines, Durham ...	Aug. 4, 1888
7*Prof. G. S. BRADY, Durham College of Science, Newcastle-upon-Tyne	Nov. 6, 1875
8 Dr. BRASSERT, Berghauptmann, Bonn-am-Rhein, Prussia ...	Dec. 8, 1883
9 JOSEPH DICKINSON, Esq., South Bank, Pendleton, Manchester	Dec. 13, 1852
10*C. LE NEVE FOSTER, Esq., H.M Inspector of Mines, Llandudno	Aug. 4, 1888
11 Prof. WILLIAM GARNETT, 13, Spring Gardens, London, S.W.	Nov. 24, 1894
12*JOHN GERRARD, Esq., H.M. Inspector of Mines, Worsley, Manchester	June 11, 1892
13*Rev. H. PALIN GURNEY, Principal, Durham College of Science, Newcastle-upon-Tyne	Jan. 19, 1895
14*HENRY HALL, Esq., H.M. Inspector of Mines, Rainhill, Lancashire	March 4, 1876
15*J. L. HEDLEY, Esq., H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne	April 9, 1892
16*Prof. A. S. HERSCHEL, Observatory House, Slough, Bucks...	Aug. 3, 1872
17*Prof. G. A. LEBOUR, Durham College of Science, Newcastle-upon-Tyne	Nov. 1, 1879
18 J. A. LONGRIDGE, Esq., Grêve d'Ayetté, Jersey	Dec. 11, 1886
19*J. S. MARTIN, Esq., H.M. Inspector of Mines, Clifton	Aug. 4, 1888
20*JOHN HERMAN MERIVALE, Togston Hall, Acklington, Northumberland	Aug. 5, 1893

Date of Election.

21*JOSEPH T. ROBSON, Esq., H.M. Inspector of Mines, Swansea ... Aug. 4, 1888
22*J. M. RONALDSON, Esq., H.M. Inspector of Mines, 44, Athole Gardens, Glasgow ... ... Aug. 4, 1888
23*A. H. STOKES, Esq., H.M. Inspector of Mines, Greenhill, Derby Aug. 4, 1888
24*PROF. H. STROUD, Durham College of Science, Newcastle-upon-Tyne ... ... Nov. 5, 1892
25 M. E. VUILLMEIN, Mines d'Aniche, Nord, France ... ... Sept. 7, 1878
26*FRANK N. WARDELL, Esq., H.M. Inspector of Mines, Wath-on-Dearne, near Rotherham ... ... Feb. 4, 1865

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Date of Election and of Transfer.

1 ABRAHAM, DAVID, Pencoedcae, Merthyr Tydvil ... ... June 8, 1895
2 ABURROW, CHARLES, P.O Box 534, Johannesburg, Transvaal Feb. 13, 1892
3 ACKROYD, WM., Morley Main Collieries, Morley, near Leeds Feb. 7, 1880
4 ADAMSON, THOS., E.I.R. Collieries, Giridih, Bengal, India Feb. 10, 1894
5 AGABEG, FRANK J., Apcar and Co.'s Collieries, Sitarampore, India ... ... Dec. 9, 1893
6 AGASSIZ, ALEXANDER, Museum of Comparative Zoology, Cambridge, Massachussets, U.S.A. ... ... Feb. 9, 1895
7 AITKIN, HENRY, Falkirk, N.B.... .. .. Mar. 2, 1865
8 ALLAN, JOHN F , P.O. Box 485, Nogales, Arizona, U.S.A. A.M. Feb. 10, 1883
M. June 8, 1889
9 ALLAN, T. ALEXANDER, c/o Messrs. Gibbs, Bright, and Co., Melbourne, Australia ... ... Feb. 11, 1893
10 ALLISON, J. J. C., Woodland Collieries, Butterknowle, R.S.O., Co. Durham ... ... A.M. Feb 13, 1886
M. June 8, 1889
11 ANDERSON, C. W., Cleadon Park, Sunderland ... ... Aug. 21, 1852
12 ANDERSON, R. HAY, Poorman Gold Mines, Limited, Superintendent's Office, Silver City, Idaho, U.S.A. ... ... Aug. 4, 1894
13 ANDERSON, R. S., Elswick Colliery, Newcastle-upon-Tyne... S. June 9, 1883
A.M. Aug. 4, 1888
M Aug. 3, 1889
14 ANGOVE, W. H., Albany, Western Australia ... ... Oct. 13, 1894
15 ANGUS, JAMES, Radcliffe, Acklington, Northumberland ... Oct. 8, 1892
16*ANGWIN, B., P.O. Box 231, Johannesburg, Transvaal ... Nov. 24, 1894
17 APPLEBY, W. R., 911, Fifth Street, S.E., Minneapolis, Minn., U.S.A. ... ... April 14, 1894
18 ARCHER, T., 6, Park Terrace, Gateshead-upon-Tyne ... July 2, 1872
19 ARCHER, WILLIAM, Victoria Garesfield, Lintz Green ... A. Aug. 6, 1892
M. Aug. 3, 1895
20 ARGALL, PHILIP, P.O. Box 1095, Denver, Colorado, U.S.A. June 21, 1894
21 ARMSTRONG, LORD, C.B., LL.D., D.C.L., Cragside, Rothbury (PAST-PRESIDENT, *Member of Council*) ... ... May 3, 1866
22 ARMSTRONG, HENRY, Chester-le-Street ... . A.M. April 14, 1883
M June 8, 1889
23 ARMSTRONG, WM., Pelaw House. Chester-le-Street (VICE-PRESIDENT, *Member of Council*) ... . Aug. 21, 1852
24 ARMSTRONG, W., Jun., Wingate, Co. Durham (*Member of Council*) ... . S. April 7, 1867
M. Aug. 6, 1870

		Date of Election and of Transfer.
25	Arnold, T., Castle Hill, Greenfields, Llanelly	A.M. Oct. 2, 1880
		M. June 8, 1889
26	Ashcroft, Harry, Borrea Coal Company, Limited, Seetarampore, Bengal, India	Aug. 4, 1894
27	Asquith, T. W., Harperley Hall, Tantobie, R.S.O., Co. Durham	Feb. 2, 1867
28	Atkinson, Claude W., Erwood, Beckenham, Kent ...	Aug. 6, 1892
29	Atkinson, L. B., Messrs. T. W. Goolden and Co., Woodfield Works, Harrow Road, London	Aug. 6, 1892
30	Atterbury, B. J., 18, Eldon Street, London, E.C.	Jan. 19, 1895
31	Aubrey, R. C., 61, Bath Street, Southport	Feb. 5, 1870
32	Austin, W. Lawrence, P.O. Box 941, Denver, Colorado, U.S.A.	June 21, 1894
33	Ayton, Ernest F., El Bote Mining Negociacion, Zacatecas, Republic of Mexico	Aug. 1, 1891
34	Ayton, Henry, 122, Rye Hill, Newcastle-upon-Tyne *(Member of Council)*	S. Mar. 6, 1875
		A.M. Aug. 2, 1884
		M. June 8, 1889
35	Bailes, E. T., Wingate, Ferryhill	A.M. June 7, 1879
		M. June 8, 1889
36	Bailes, T., Jesmond Gardens, Newcastle-upon-Tyne ...	Oct. 7, 1858
37	Bailey, Samuel, 30, Waterloo Street, Birmingham ...	June 2, 1859
38	Bain, R. Donald, 85, Pembroke Road, Clifton, Bristol ...	S. March 1, 1873
		M. Aug. 5, 1876
39	Bainbridge, E., Nunnery Colliery Offices, Sheffield *(Member of Council)*	S. Dec. 3, 1863
		M. Aug. 1, 1868
40	Banks, Thomas, 60, King Street, Manchester	Aug. 4, 1877
41	Barker, M. W., P.O. Box 1463, Johannesburg, Transvaal	Apr. 8, 1893
42	Barrett, C. R., Whitehill Hall, Chester-le-Street	S. Nov. 7, 1874
		A.M. Aug. 7, 1880
		M. Dec. 11, 1886
43*	Bartholomew, C. W., Blakesley Hall, near Towcester ...	Dec. 4, 1875
44	Bates, Sidney, Mickley Colliery Offices, Stocksfield-upon-Tyne	A. Feb. 8, 1890
		M. June 8, 1895
45	Bates, Thomas, The Grange, Prudhoe-upon-Tyne	Feb. 9, 1895
46	Batey, John, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
47	Baumgartner, W. O., Whitburn, near Sunderland ...	S. Sept. 6, 1879
		M. Aug. 3, 1889
48	Bayldon, Daniel Hy., 3, Drapers' Gardens, London, E.C.; letters to Spitzkop Farm Gold Company, Limited, Spitzkop, Lydenburg, S.A.R.	Feb. 8, 1890
49	Beanlands, Arthur, Palace Green, Durham	Mar. 7, 1867
50	Bell, Sir Lowthian, Bart., Rounton Grange, Northallerton (Past-President, *Member of Council)*	July 6, 1854
51	Bell, C. E., Park House, Durham	S. Dec. 3, 1870
		M. Oct. 4, 1879
52	Bell, Geo. F., H. M. Inspector of Mines, 30, Eldon Street, Newcastle-upon-Tyne	S. Sept. 6, 1879
		A.M. Aug. 6, 1887
		M. Aug. 3, 1889
53	Bell, R. G., 42, Burdon Terrace, Newcastle-upon-Tyne ...	April 14, 1894

Date of Election and of Transfer.

54 Bell, Walter, Ashington Colliery, Morpeth ... ... S. Oct. 8, 1889
M. Feb. 10, 1894

55 Bellingham, George, Bayley Street, Coolgardie, Western Australia .. .. Nov. 24, 1894

56 Bennett. Alfred H., Dean Lane Collieries, Bedminster, Bristol ... ... A.M. April 10, 1886
M. June 8, 1889

57 Benson, J. G., 12, Grey Street, Newcastle-upon-Tyne ... Nov. 7, 1874

58 Benson, T. W., 11, Newgate Street, Newcastle-upon-Tyne (Retiring Vice-President, *Member of Council)* ... Aug. 2, 1866

59 Berkley, C., Marley Hill, Swalwell, R.S.O., Co. Durham (Vice-President, *Member of Council)* ... ... Aug. 21, 1852

60 Berkley, Frederick, Lumley Thicks, Fence Houses ... A.M. Dec. 9, 1882
M. June 8, 1889

61 Berkley, R. W., Marley Hill, Swalwell, R.S.O., Co. Durham ... ... A.M. Aug. 7, 1880
M. June 8, 1889

62 Bewick, T. J., Broad Street House, Old Broad Street, London, E.C. ... ... April 5, 1860

63 Beynon, J. C. S., P.O. Box 1364, Johannesburg, Transvaal June 10, 1893

64 Bibby, Wm., Raub Australian Gold Mining Company, Limited, Raub, Pahang, Malay Peninsula ... ... Jan. 19, 1895

65 Bigg-Wither, Harris, 10, Swinley Road, Wigan, Lancashire Jan. 19, 1895

66 Bigge, D. Selby, 27, Mosley Street, Newcastle-upon-Tyne... June 13, 1891

67 Bigland, J., Henknowle, Bishop Auckland ... ... June 3, 1857

68 Bilgrami, Syed Ali Shamsul Ulama, Director-General of Mines, Hyderabad, Deccan, India ... ... April 11, 1891

69 Bishop, James, Grey Valley Coal Co., Brunnerton, Greymouth, New Zealand ... ... April 13, 1889

70 Bitzos, N. J., c/o A. G. Sourlas, Balouk Bazaar, Constantinople ... ... S. Feb. 14, 1891
M. April 14, 1894

71 Black, W., 1, Lovaine Place, Newcastle-upon-Tyne ... April 2, 1870

72 Blackburn, Wm. Stevenson, Aire Villas, Astley, Woodlesford, near Leeds ... ... Dec. 10, 1887

73 Blackett, W. C., Acorn Close, Sacriston, Durham *(Member of Council)* ... ... A.M. Aug. 1, 1885
M. June 8, 1889

74 Blakeley, A. B., Soothill Wood Coll. Co., Ltd., near Batley S. Feb. 15, 1879
M. Aug. 3, 1889

75 Bolam, Philip, North Walbottle Colliery, Newcastle-upon-Tyne ... ... A. Dec. 12, 1891
M. Aug. 3, 1895

76 Bolton, Edgar Ormerod, Executor of Col. Hargreaves, Colliery Offices, Burnley ... ... April 12, 1890

77 Bolton, H. H., Newchurch Collieries, near Manchester ... Dec. 5, 1868

78 Boole, George, Rainford, near St. Helens, Lancashire ... Jan. 19, 1895

79 Borlase, W. H., Brown How, Ulleswater, Glenridding, near Penrith ... ... Aug. 4, 1894

80 Boucher, A. S., Kempsey House, near Worcester ... ... Aug. 4, 1883

81 Bradford, Geo., Norton Palms, Darlington ... ... Oct. 11, 1890

82 Bramwell, Hugh, Great Western Colliery, near Pontypridd, Glamorganshire ... . A.M. Aug. 6, 1887
M. Aug. 3, 1889

	Date of Election and of Transfer.
83 Breakell, Thomas, Brassington, near Derby	Feb. 11, 1893
84 Breckon, J. R., 53, John Street, Sunderland	Sept. 3, 1864
85 Britten, T. J., P.O. Box 494, Johannesburg, Transvaal	June 21, 1894
86 Broja, Richard, Geheimer Bergrath, 77, Kaiser-Wilhelm-strasse, Breslau, Germany	Nov. 6, 1880
87 Bromley, A. H., Llanuwchllyn, near Bala, North Wales ...	Nov. 24, 1894
88*Brough, Bennett H., 28, Victoria Street, London, S.W. ...	A.M. Dec. 10, 1887
	M. June 8, 1889
89 Brough, Thomas, New Seaham Colliery, Sunderland ...	S. Feb. 1, 1873
	A.M. Aug. 2, 1879
	M. June 8, 1889
90 Brown, Archibald T., 372, Flinders Lane, Melbourne ...	Aug. 5, 1893
91 Brown, M. Walton, Westmorlands, Gateshead-upon-Tyne (Secretary)	S. Oct. 7, 1871
	M. Aug. 3, 1878
92 Brown, R. G., P.O. Box 946, Butte, Montana, U.S.A. ...	Feb. 9, 1895
93 Brown, Robert M., Norwood Colliery, *via* Darlington ...	A.M. Oct. 10, 1886
	M. Aug. 3, 1889
94 Brown, Thomas, District Manager, Westport Coal Co., Millerton, Westport, New Zealand	April 13, 1889
95 Brown, Thos. Forster, Guildhall Chambers, Cardiff ...	Aug. 1, 1861
96 Brown, Westgarth Forster, Alston House, Parade, Cardiff	S. Aug. 6, 1887
	M. Aug. 5, 1893
97 Browne, Sir Benjamin C., Westacres, Benwell, Newcastle-upon-Tyne. Transactions to Free Library, Newcastle-upon-Tyne	Oct. 1, 1870
98 Browne, R. J., Barakar, East India Railway, Bengal ...	Oct. 8, 1892
99 Bruce, John, Port Mulgrave, Hinderwell, R.S.O., Yorkshire	S. Feb. 14, 1874
	A.M. Aug. 7, 1880
	M. June 8, 1889
100 Bryham, W., Douglas Bank Collieries, Wigan	Aug. 3, 1865
101 Buglass, J., Stobswood, *via* Acklington, Northumberland	A. Dec. 10, 1892
	M. Aug. 3, 1895
102 Bulman, E. H., P.O. Box 357, Johannesburg, Transvaal ...	Feb. 13, 1892
103 Bulman, H. F., Byer Moor, Burnopfield, near Newcastle-upon-Tyne	S. May 2, 1874
	A.M. Aug. 6, 1881
	M. June 8, 1889
104 Bunkell, Henry B., Violet Mine, Krugersdorf, South Africa	April 8, 1893
105 Bunning, C. Z., c/o The Borax Co., Limited, 2, Macri Khan, Constantinople	S. Dec. 6, 1873
	A.M. Aug. 5, 1882
	M. Oct. 8, 1887
106*Burls, Herbert T., P.O. Box 57, Klerksdorp, South African Republic	Feb. 9, 1889
107 Burn, Frank H., West Cliff, Elmfield Road, Gosforth, Newcastle-upon-Tyne	S. Feb. 9, 1889
	A. Aug. 4, 1894
	M. Aug. 3, 1895
108 Burn, James, 28, Fawcett Street, Sunderland	Dec. 13, 1890
109*Burns, David, Stanwix, Carlisle	May 5, 1877
110 Burrows, J. S., Green Hall, Atherton, near Manchester ...	S. Oct. 11, 1873
	M. Aug. 4, 1877
111 Butters, Charles, P.O. Box 1891, Johannesburg, Transvaal	Feb. 10, 1894

		Date of Election and of Transfer.
112	CALVERT, A. F., The Mount, Oseney Crescent, Camden Road, London, N.W.	April 14, 1894
113	CAMERON, IAN, Sudbury, Ontario, Canada	Aug. 4, 1894
114	CAMPBELL, H. H., Sutton Hall, St. Helens, Lancashire ...	Jan. 19, 1895
115	CAMPBELL, W. YOUNG, P.O. Box 357, Johannesburg, Transvaal	Apr. 8, 1893
116	CAMPBELL-JOHNSTON, R. C., P.O. Box 40, Vancouver, British Columbia	Nov. 24, 1894
117*	CANDLER, T. E., East Lodge, Crook, *via* Darlington ...	S. May 1, 1875
		A.M. Aug. 4, 1883
		M. June 8, 1889
118	CARNES, CHARLES SPEARMAN, Cornwall House, Murton Colliery, Sunderland	Aug. 1, 1891
119	CARR, T., Lilywhite Terrace, Four Lane Ends, Hetton-le-Hole, R.S.O., Co. Durham	Feb. 10, 1894
120	CARRALL, J. WILCOCKS, Acting Commissioner of the Amoy Customs, Amoy, China	Aug. 4, 1894
121	CHALMERS, J. A., P.O. Box 357, Johannesburg, Transvaal	Dec. 9, 1893
122	CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield...	Mar. 6, 1869
123	CHAPMAN, ALFRED CRAWHALL, 29, St. Nicholas' Buildings, Newcastle-upon-Tyne...	Oct. 13, 1888
124	CHAPMAN, H. R., Victoria Works, Gateshead-upon-Tyne ...	Nov. 24, 1894
125	CHARLETON, A. G., Dashwood House, New Broad Street, London, E.C.	Aug. 6, 1892
126	CHARLTON, WM., Linares, Provincia de Jaen, Spain ...	April 8, 1893
127	CHATER, JOSEPH, Bengal Nagpur Coal Co., Limited, Evelyn Lodge, Kumarpur, Asansol, Bengal, India	Dec. 9, 1893
128	CHEESMAN, E. TAYLOR, Shire Moor Colliery, Northumberland	A. Aug. 2, 1890
		M. Aug. 6, 1892
129	CHEESMAN, HERBERT, Hartlepool	Aug. 6, 1892
130	CHEESMAN, I. T., Throckley Colliery, Newcastle-upon-Tyne	Feb. 1, 1873
131	CHEESMAN, W. T., Hartlepool	Feb. 5, 1876
132	CHICKEN, LANCELOT W., Boldon Colliery, Co. Durham ...	June 8, 1889
133	CHILDE, HENRY S., Mining Engineer, Wakefield	A.M. Feb 12, 1887
		M. Aug. 3, 1889
134	CLARK, C. F., Garswood Coal and Iron Co., Ltd., near Wigan	Aug. 2, 1866
135	CLARK, R. B., Springwell Colliery, Gateshead-upon-Tyne ...	S. May 3, 1873
		M. Aug. 4, 1877
136	CLIFFORD, WM., Pittsburg, Pennsylvania, U.S.A.	Feb. 9, 1895
137	CLOUGH, JAMES, Bomarsund House, Bomarsund, Bedlington, R.S.O.	S. April 5, 1873
		A.M. Aug. 3, 1878
		M. June 8, 1889
138	COCHRANE, B., Aldin Grange, Durham	Dec. 6, 1866
139	COCHRANE, C., Green Royde, Pedmore, near Stourbridge ...	June 3, 1857
140	COCHRANE, NAPIER, Aldin Grange, Durham	S. Dec. 8, 1888
		M. Feb. 10, 1894
141	COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council)*	Aug. 1, 1861
142	COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan	A.M. April 22, 1882
		M. Aug. 3, 1889

	Date of Election and of Transfer.
143 Coghlan, F. M., Catorce, S.L.P., Mexico	Dec. 9, 1893
144 Collins, Arthur Launcelot, 14 & 15, Broad Street Avenue, London, E.C.	Feb. 13, 1892
145 Collins, Horatio, P.O. Box 735, Johannesburg, Transvaal	Aug. 4, 1894
146*Collins, H. B., Garscaddin, by New Kilpatrick, Dumbartonshire	April 14, 1894
147 Colquhoun, T., West Stanley Colliery, Co. Durham ...	Dec. 14, 1889
148 Commans, R. E., 6, Queen Street Place, London, E.C. ...	Nov. 24, 1894
149 Cook, J., Washington Iron Works, Washington, Co. Durham	May 8, 1869
150 Cook, J. Watson, Greenfield House, Crook	Oct. 14, 1893
151 Corbett, V. W., Chilton Moor, Fence Houses	Sept. 3, 1870
152 Corbitt, M., 1, Abbotsford Terrace, Newcastle-upon-Tyne	Dec. 4, 1875
153 Cork, F. Lawrence, Bengal Nagpur Coal Company, Limited, Barrakur, Bengal, East India	Dec. 9, 1893
154 Corlett, George Stephen, Wigan	Dec. 12, 1891
155 Coulson, F., 10, Victoria Terrace, Durham	S. Aug. 1, 1868 M. Aug. 2, 1873
156 Coulthard, Francisco, Minas del Penoncillo, Marbella, Provincia de Malaga, Spain	June 8, 1889
157 Cox, John H., 10, St. George's Square, Sunderland	Feb. 6, 1875
158 Craven, Hiram, Jun., Mechanical Engineer, Sunderland ...	April 12, 1890
159 Crighton, John, 20, Exchange Buildings, St. Mary's Gate, Manchester	Oct. 8, 1887
160 Crone, E. W., Killingworth, near Newcastle-upon-Tyne ...	S. Mar. 5, 1870 M. Aug. 5, 1876
161 Crone, J. R., Tudhoe House, *via* Spennymoor *(Member of Council)*	Feb. 1, 1868
162 Crone, S. C., Forest Hall, Newcastle-upon-Tyne	Aug. 3, 1854
163 Cross, John, 77, King Street, Manchester	June 5, 1869
164 Croudace, C. J., Bettisfield Colliery Co., Limited, Bagillt, North Wales	Nov. 2, 1872
165 Croudace, T., West House, Haltwhistle	Dec. 9, 1893
166 Croudace, Thomas, Lambton Lodge, Lambton, Newcastle, New South Wales	Nov. 6, 1862
167 Curry, W. Thos., Thornton House, Serpentine Road, Newport, Mon.	S. Sept. 4, 1880 A.M. Aug. 7, 1886 M. Aug. 3, 1889
168 Dacres, Thomas, c/o Mrs, Dacres, Dolgwyddfa, Newbridge, Newport, Monmouthshire	May 4, 1878
169 Daglish, John, Rothley Lake, Cambo, R.S.O., Northumberland (Past-President, *Member of Council*)	Aug. 21, 1852
170 Dakers, W. R., The Loggins, Tudhoe Colliery, *via* Spennymoor, Durham	A.M. Oct. 14, 1882 M. Aug. 3, 1889
171 Dale, Sir David, Bart., West Lodge, Darlington	Feb. 5, 1870
172 Dan, Takuma, c/o Mitsui Mining Company, No. 4 Surugacho, Nihonbashi-Ku, Tokio, Japan	April 14, 1894
173 Dangar, J. Hubert	April 8, 1893
174 Daniel, Peter Francis, Greymouth, New Zealand ...	April 8, 1893
175 Darby, G. M., Katras Kerria Coal Company, Limited, Katras P.O., *via* Burrakur, India	Aug. 4, 1894

		Date of Election and of Transfer.
176	DARBY, J. H., Pen y Garth, Brymbo, Denbighshire... ...	Feb. 9, 1895
177	DARLING, FENWICK, South Durham Colliery, Darlington ...	Nov. 6, 1875
178	DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales	S. Nov. 7, 1874 M. Aug. 4, 1877
179	DAVEY, GEORGE, c/o Michoacan Railway and Mining Company, Las Trojes, Ocampo, Michoacan, Mexico ...	June 10, 1893
180	DAVEY, HY., 3, Princes Street, Westminster, London, S.W.	Oct. 11, 1873
181	DAVIES, D. E., Cwmaman Colliery, Aberdare	Feb. 9, 1895
182	DAVIES, Lt.-Col. JASPER G. S., Marton, Middlesbrough ...	Aug. 3, 1889
183	DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland...	April 10, 1886
184	DAVIES, J. HUBERT, P.O. Box 455, Johannesburg, Transvaal	April 8. 1893
185	DAVIS, KENNETH MCRAE, Dudley Colliery, Northumberland	April 13, 1889
186	DAVISON, J. FORD, Yarlside, Dalton-in-Furness	Oct. 13, 1894
187	DEES, J. GIBSON, Floraville, Whitehaven	Oct. 13, 1883
188	DEES, R. R., Newcastle-upon-Tyne	Oct. 7, 1871
189	DELPRAT, G. D., Campanas No. 15, Cordoba, Spain ...	Feb. 10, 1894
190	DENNY, G. A., Farm Tusschenby, Denny Dalton Gold Field, Vryheid District, Transvaal	Dec. 8, 1894
191	DICKINSON, ARTHUR, Warham Road, South Croydon, Surrey	April 14, 1894
192	DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea	Nov. 2, 1872
193*	DIXON, JAMES S., 97, Bath Street, Glasgow	Aug. 3, 1878
194	DIXON, JONATHAN, Maitland Street, Stockton, *via* Newcastle, New South Wales	Oct. 13, 1894
195	DIXON, R., 4, Tynevale Terrace, Gateshead-upon-Tyne ...	June 5, 1875
196	DIXON-BROWN, A. D., Unthank Hall, Haltwhistle	Dec. 10, 1892
197	DOBB, T. G., Derby Terrace, Hindley, near Wigan, Lancashire	Dec. 8, 1894
198	DOBBS, JOSEPH, Jarrow Colliery, Castle Comer, Co. Kilkenny	April 14, 1894
199	DODD, B., Bearpark Colliery, near Durham	S. May 3, 1866 M. Aug. 1, 1868
200	DODD, CYRIL H., St. Helens Colliery, Bishop Auckland ...	Aug. 6, 1892
201	DODD, M., Burncroft, Hexham	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
202*	DONKIN, W., c/o A. M. Appleten, 10, Western Hill, Durham	S. Sept. 2, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
203*	DOUGLAS, C. P., Thornbeck Hill, Carmel Road, Darlington	Mar. 6, 1869
204	DOUGLAS, JOHN, 4, Brandling Terrace, Felling, R.S.O., Co. Durham	A.M. April 22, 1882 M. Aug. 3, 1889
205	DOUGLAS, M. H., Usworth Colliery, Washington, R.S.O., Co. Durham	A.M. Aug. 2, 1879 M. Aug. 3, 1889
206	DOUGLAS, T., The Garth, Darlington (PRESIDENT, *Member of Council)*	Aug. 21, 1852
207	DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ...	S. April 5, 1873 M. Aug. 7, 1875
208	DOYLE, PATRICK, *Indian Engineering*, 19, Lall Bazar, Calcutta, India	A.M. Mar. 1, 1879 M. Aug. 3, 1889
209	DUDLEY, URIAH, P.O. Box 110, Broken Hill, New South Wales	April 14, 1894
210	DUMAT, ALFRED, 1, Loop Street, Pietermaritzburg, Natal	April 8, 1893
211	DYSON, T. INGLEBY, Mount Morgan, Queensland	Feb. 9, 1895

		Date of Election and of Transfer.
212	EASTLAKE, ARTHUR W., Balham, London	June 11, 1892
213	ECK, RICHARD, Pinner, R.S.O., Middlesex	Aug. 5, 1893
214	EDEN, C. H., c/o Messrs. Vivian and Sons, Swansea ...	June 14, 1890
215	EDGE, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop	A.M. Sept. 7, 1878 M. Aug. 3, 1889
216	EDWARDS, EDWARD, Maindy Pit, Ocean Coal Company, Ton Pentre, South Wales	Feb. 9, 1895
217	ELLIS, W. R., Wigan	June 1, 1878
218	ELSDON, ROBERT, The Highlands, Burnt Ash Hill, Lee, Kent	Nov. 7, 1876
219	ELWEN, THOMAS LEE, Littleburn Colliery, near Durham ...	Oct. 13, 1888
220	EMBLETON, H. C., Central Bank Chambers, Leeds	April 14, 1894
221	EMBLETON, T. W., The Cedars, Methley, Leeds	S. Sept. 2, 1865 M. Aug. 1, 1868
222	EMINSON, J. B., Londonderry Offices, Seaham Harbour ...	Mar. 2, 1872
223	ETHERINGTON, J., 39A, King William Street, London Bridge, London, E.C.	Dec. 9, 1893
224	EVANS, E. W., P.O. Box 357, Johannesburg, Transvaal ...	April 8, 1893
225	EVANS, LEWIS, P.O. Box 601, Johannesburg, Transvaal ...	Oct. 14, 1893
226	EVERARD, J. B., 6, Millstone Lane, Leicester	Mar. 6, 1869
227	FAIRLEY, JAMES, Craghead and Holmside Colliery, Chester-le-Street	A.M. Aug. 7, 1880 M. Aug. 3, 1889
228	FARAGHER, LOUIS, Cape Copper Co., Limited, Ookiep, Namaqualand, South Africa	April 8, 1893
229	FARMER, A., Seaton Carew, near West Hartlepool	Mar. 2, 1872
230	FAULDER, JOSEPH, Bolton Colliery, Mealsgate, *via* Carlisle...	Aug. 6, 1892
231*	FENWICK, BARNABAS, 84, Osborne Road, Newcastle-upon-Tyne	Aug. 2, 1866
232	FERENS, FREDERICK J., Silksworth Colliery, Sunderland ...	S. Dec. 4, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
233	FERENS, F. S., 13, Railway Arches, Westgate Road, Newcastle-upon-Tyne	Oct. 14, 1893
234	FERGIE, CHAS., Drummond Colliery, Westville, Nova Scotia	Dec. 9, 1893
235	FERGUSON, D., c/o James Ferguson, 115, Buccleuch Street, Glasgow	A.M. Dec. 8, 1883 M. Aug. 3, 1889
236	FISHER, ED. R., Nant Glas, Cross Hands, near Llanelly, South Wales	A.M. Aug. 2, 1884 M. Aug. 3, 1889
237	FISHWICK, R., Bincnester Colliery, Co. Durham	Aug. 6, 1892
238	FLEMING, C. E., Black, Hawthorn, and Co., Gateshead-upon-Tyne	April 13, 1889
239	FLETCHER, H., Ladyshore Colliery, Little Lever, Bolton, Lancashire	Aug. 3, 1865
240	FLETCHER, JAMES, Whickham and Bullock Island Coal Co., Limited, Carrington, New South Wales	Dec. 9, 1893
241	FLETCHER, LANCELOT, Brigham Hall, Carlisle	A.M. April 14, 1888 M. June 8, 1889
242	FLINT, JOHN, Broomhill Colliery, Acklington, Northumberland	Jan. 19, 1895
243	FOGGIN, W., 12, Devonshire Place, Jesmond, Newcastle-upon-Tyne	Mar. 6, 1875

Date of Election and of Transfer.

244 FORD, STANLEY H., c/o City and Suburban Gold Mining Co., P.O. Box 28, Johannesburg, Transvaal. Transactions, etc., to c/o F. G. Ford, 19, North Street, Bristol ... June 10, 1893

245 FORREST, J. C., Holly Bank Coll., Essington, Wolverhampton April 12, 1884

246 FORSTER, G. B., 3, Eldon Square, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council)* ... ... Feb. 5, 1857

247 FORSTER, J. R., Water Company's Office, Newcastle-upon-Tyne ... ... July 2, 1872

248 FORSTER, J. T. ... ... S. Aug. 1, 1868
M. Aug. 5, 1876

249 FORSTER, THOMAS E., 3, Eldon Square, Newcastle-upon-Tyne S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

250 FOWLER, R., Washington Colliery, Washington Station, R.S.O., Co. Durham... ... ... Nov. 24, 1894

251 FRYAR, MARK, Denby Colliery, Derby ... ... S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889

252 GALLOWAY, T. LINDSAY, Argyll Colliery, Campbeltown, N.B. Sept. 2, 1876

253 GALLOWAY, WM., Cardiff ... ... April 23, 1887

254 GALLWEY, ARTHUR P., P.O. Box 138, Johannesburg, Z.A.R. S. Oct. 2, 1880
M. Oct. 10, 1891

255 GARDINER, E. T., 8, South View Terrace, Bishop Auckland Dec. 8, 1894

256 GEDDES, GEORGE H., 142, Princes Street, Edinburgh ... Oct. 1, 1881

257 GERRARD, JAMES, 11, Meek Buildings, Wigan ... ... S. Mar. 1, 1873
A.M. Aug. 2, 1879
M. June 8, 1889

258 GERRARD, JOHN, Worsley, Manchester ... ... S. Mar. 5, 1870
M. Aug. 1, 1874

259 GIFFORD, HENRY J., Minas de Passagem, Ouro Preto, Brazil Oct. 14, 1893

260 GILCHRIST, J. R., Garesfield Colliery, Lintz Green, Newcastle-upon-Tyne ... ... S. Feb. 3, 1877
A.M. Aug. 1, 1885
M. June 8, 1889

261 GILLETT, LEONARD F., 163, Osmaston Road, Derby ... June 14, 1890

262 GILLMAN, FRITZ, Gartenstrasse, 1, Freiburg im/B., Baden, Germany ... ... A.M. Dec. 8, 1894
M. June 8, 1895

263 GILROY, S. B., Markham Collieries, Duckmanton ... ... Sept. 5, 1868

264 GJERS, JOHN, Southfield Villas, Middlesbrough ... ... June 7, 1873

265*GLEDHILL, EDWARD, 1, Cranbury Avenue, Southampton ... Dec. 9, 1893

266 GOERZ, A., P.O. Box 1961, Johannesburg, Transvaal ... April 14, 1894

267 GOOLDEN, WALTER T., 3, Whitehall Place, London, S.W. ... Aug. 6, 1892

268 GOULDIE, JOSEPH, The North-Eastern Bullfontine, Kimberley, South Africa ... . Aug. 5, 1893

269 GREAVES, J. O., St. John's, Wakefield ... ... Aug. 7, 1862

270 GREEN, J. T., Southside, Sneyd Park, Clifton, Bristol ... Dec. 3, 1870

271 GREENER, HENRY, South Pontop Colliery, Annfield Plain... A.M. Dec. 9, 1882
M Aug. 3, 1889

272 GREENER, T. Y., West Lodge, Crook, Darlington ... ... S. July 2, 1872
A.M. Aug. 2, 1879
M. June 8, 1889

	Date of Election and of Transfer.
273 Greenwell, G. C., Jun., Poynton, near Stockport	S. Mar. 6, 1869
	M. Aug. 3, 1872
274 Gregson, G. Ernest, 11, Chapel Street, Preston, Lancashire	A.M. Dec. 8, 1894
	M. Feb. 9, 1895
275 Gresley, W. S., Erie, Pa., U.S.A.	A.M. Oct. 5, 1878
	M. Aug. 3, 1889
276 Grey, C. G., Ballycourcy, Enniscorthy, Co. Wexford ...	May 4, 1872
277 Griffith, N. R., Plasnewydd, Ruabon, North Wales ...	Aug. 1, 1867
278 Griffith, Wm., Waterloo House, Aberystwyth, South Wales	Dec. 9, 1893
279 Grimshaw, E. J., 23, Hardshaw Street, St. Helen's, Lancashire	Sept. 5, 1868
280 Guthrie, James K., Eltringham Colliery, Prudhoe, R.S.O.	Aug. 3, 1889
281 Haddock, W. T., Jun., New Primrose Gold Mining Co., Limited, P.O. Box 590, Johannesburg, Transvaal ...	S. Oct. 7, 1876
	A.M. Aug. 1, 1885
	M. June 8, 1889
282 Hadfield, Joseph, Holly Bank, Over Hulton, near Bolton, Lancashire	Feb. 9, 1895
283 Haggie, D. H., Wearmouth Patent Rope Works, Sunderland	Mar. 4, 1876
284 Haggie, Peter Sinclair, Gateshead-upon-Tyne	A.M. April 14, 1883
	M. Aug. 3, 1889
285* Hague, Ernest, Castle Dyke, Sheffield	Aug. 3, 1878
286 Halder, Albert H., Buluwayo, British Matabeleland ...	April 8, 1893
287 Hall, Frederick, Fernleigh, Highfield, Workington ...	Oct. 14, 1893
288 Hall, Fred. W., Haswell Lodge, Sunderland	S. June 8, 1889
	M. Feb. 10, 1894
289 Hall, John Charles, Pegswood Colliery, near Morpeth ...	A. Dec. 14, 1889
	M. Aug. 3, 1895
290 Hall, M., Lofthouse Station Collieries, near Wakefield ...	Sept. 5, 1868
291 Hall, M. S., 8, Victoria Street, Bishop Auckland	Feb. 14, 1874
292 Hall, Tom, Ryhope Colliery, *via* Sunderland	June 8, 1889
293 Hall, William F., Haswell Colliery, Haswell, *via* Sunderland (Retiring Vice-President, *Member of Council*) ...	May 13, 1858
294 Hallas, G. H., Wigan and Whiston Coal Co., Limited, Prescot	S. Oct. 7, 1876
	A.M. Aug. 4, 1883
	M. June 8, 1889
295 Hallimond, Wm. Tasker, P.O. Box 344, Johannesburg, Transvaal	Dec. 14, 1889
296 Halse, Edward, Apartado, 512, Mexico, D.F.	A.M. June 13, 1885
	M. Aug. 3, 1889
297 Hamilton, E., Rig Wood, Saltburn-by-the-Sea	S. Nov. 1, 1873
	A.M. Aug. 2, 1879
	M. June 8, 1889
298 Hancock, H. R., Leetown, Horrabridge, Devonshire ...	A.M. Aug. 4, 1894
	M. Nov. 24, 1894
299 Hannah, David, Brynderwen, Ferndale, South Wales ...	Feb. 9, 1895
300 Hardman, John E., 83, Hollis Street, Halifax, Nova Scotia	Dec. 9, 1893
301 Hare, Samuel, Bedlington Collieries, Bedlington, R.S.O....	S. Aug. 2, 1879
	M. Aug. 1, 1891
302 Hargreaves, Joseph, Gwaun Cae Gurwen Collieries, Brynamman, R.S.O.	Aug. 5, 1893

		Date of Election and of Transfer.
303	HARLE, PETER, Page Bank Colliery, Co. Durham	Oct. 8, 1892
304	HARLE, RICHARD, Browney Colliery, Durham	April 7, 1877
305	HARRIS, G. E., Margherita, Debrugarh, Upper Assam ...	Feb. 10, 1894
306	HARRIS, W. S., Kibblesworth, Gateshead-upon-Tyne ...	S. Feb. 14, 1874
		A.M. Aug. 7, 1880
		M. June 8, 1889
307	HARRISON, C. A., North Eastern Railway, Newcastle-upon-Tyne	June 21, 1894
308	HARRISON, G. B., Swinton, near Manchester	Aug. 6, 1892
309	HARRISON, W. B., Brownhills Collieries, near Walsall ...	April 6, 1867
310	HARVEY, W. PELLEW, Vancouver, British Columbia ...	June 8, 1895
311	HAY, J., Jun., Widdrington Colliery, Acklington	S. Sept. 4, 1869
		M. Aug. 4, 1874
312	HEAD, JEREMIAH, 47, Victoria Street, Westminster, London, S.W.	Aug. 3, 1889
313	HEAP, R. SMITH, 2, Nelson Square, Burnley	June 21, 1894
314	HEDLEY, J. L., H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (VICE-PRESIDENT, *Member of Council)*	S. Feb. 5, 1870
		M. Aug. 2, 1873
315	HEDLEY, SEPT. H., Langholme, Roker, Sunderland ...	S. Feb. 15, 1879
		A.M. Aug. 1, 1885
		M. Aug. 3, 1889
316	HEDLEY, W. H., Medomsley, R.S.O., Co. Durham *(Member of Council)*	Aug. 3, 1865
317	HENDERSON, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
318	HENDERSON, Jos. J., U.S. Engineer's Office, Kingsbridge, New York, U.S.A.	June 13, 1891
319	HENDY, J. C. B., Etherley, *via* Darlington	Oct. 14, 1893
320	HEPPELL, T., Leafield House, Birtley, Chester-le-Street ...	Aug. 6, 1863
321	HESLOP, C., Woodside, Marske Mill Lane, Saltburn-by-the-Sea	S. Feb. 1, 1868
		M. Aug. 2, 1873
322	HESLOP, GRAINGER, Deptford Hall, Sunderland	Oct. 5, 1872
323	HESLOP, MICHAEL, Rough Lea Colliery, Willington, Co. Durham	A. Feb. 10, 1894
		M. June 21, 1894
324	HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington	S. Oct. 2, 1880
		A.M. Aug. 4, 1888
		M. Aug. 3, 1889
325*	HEWITT, G. C., Serridge House, Coalpit Heath, near Bristol	June 3, 1871
326	HEWLETT, A., Haseley Manor, Warwick	Mar. 7, 1861
327	HIGBY, ROBERT GEORGE, Borrea Coal Co., Limited, Sitarampore, Bengal, East India Railway, India ...	Dec. 9, 1893
328	HIGSON, JACOB, 18, Booth Street, Manchester	Aug. 7, 1862
329	HILL, WILLIAM, The Pooley Hall Colliery Co., Polesworth, near Tamworth	A.M. June 9, 1883
		M. Aug. 3, 1889
330*	HILTON, J., 67, Hawkshead Street, Southport	S. Dec. 7, 1867
		M. Aug. 6, 1870
331	HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan	Aug. 3, 1865
332	HODGE, FRANCIS, 7, Roskear Villas, Camborne, Cornwall ...	April 14, 1894
333	HODGSON, JOHN, Edmondsley Colliery, Chester-le-Street ...	Oct. 8, 1889
334	HOLLIDAY, MARTIN F., Langley Grove, Durham	May 1, 1875
335	HOLLIS, HENRY WM., Whitworth House, Spennymoor ...	June 8, 1889

Date of Election and of Transfer.

336 Holmes, C., Grange Hill, near Bishop Auckland ... ... April 11, 1874
337 Holt, John, Jun., 109, Manchester Road, Swinton, Lancashire, and The Hollies, Heywood, Lancashire .. ... Aug. 5, 1893
338 Hood, A., 6, Bute Crescent, Cardiff ... ... May 2, 1861
339 Hooper, Ed., c/o J. H. Hooper, College Precincts, Worcester A.M. June 4, 1881
M. April 14, 1894
340 Hooper, G. C., Whitehaven Collieries, Whitehaven ... A.M. Aug. 4, 1894
M. Oct. 13, 1894
341 Hopkins, Edward, 13, Harrington Gardens, London, S.W. Oct. 8, 1889
342 Hosking, James, Roskear, Camborne, Cornwall .. ... June 21, 1894
343 Hoskold, H. D., Inspector General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Casilla Correos, 900, Buenos Ayres April 1, 1871
344 Houlgate, J. Kerr, 69, Lowther Street, Whitehaven ... April 8, 1893
345 Howes, Frank T., Singareni Collieries, Hyderabad Deccan A. Dec. 10, 1892
Co., Secunderabad, India ... ... M. Oct. 14, 1893
346 Hull, Prof. Edward, 20, Arundel Gardens, London, W. ... Dec. 8, 1894
347 Humble, William, Coal-fields Office, Newcastle, New South Wales ... ... Oct. 14, 1893
348 Hurst, George, 58, Eldon Street, Newcastle-upon-Tyne ... S. April 14, 1883
M. Aug. 1, 1891

349 Jackson, W. G., Hicklam House, Aberford, near Leeds ... June 7, 1873
350 Jeffcock, T. W., 18, Bank Street, Sheffield ... ... Sept. 4, 1869
351 Jenkins, W., Ocean Collieries, Treorky, Glamorganshire ... Dec. 6, 1862
352 Jepson, H., 20, The Avenue, Durham ... ... S. July 2, 1872
A.M. Aug. 2, 1879
M. June 8, 1889
353*Jobling, Thos. E., Croft Villa, Blyth, Northumberland ... S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889
354*Johns, J. Harry, P.O. Box 1021, Johannesburg, Transvaal June 21, 1894
355 Johnson, Guy R., Longdale, Alleghany County, Virginia, U.S.A. ... ... Aug. 4, 1894
356 Johnson, J., The Terrace, Stairfoot, near Barnsley ... Mar. 7, 1874
357 Johnson, W., Abram Colliery, Wigan ... ... S. Feb. 14, 1874
A.M. Aug. 2, 1879
M. June 8, 1889
358 Johnson, Wm., Radcliffe Colliery, Acklington, Northumberland ... ... Dec. 9, 1882
359 Johnston, J. Howard, c/o Messrs. Backus and Johnston, Lima, Peru, South America ... ... Feb. 10, 1894
360 Joicey, J. G., Forth Banks West Factory, Newcastle-upon-Tyne ... ... April 10, 1869
361 Joicey, W. J., Sunningdale Park, Berkshire ... ... Mar. 6, 1869
362 Jones, Jacob Carlos, Bellambi, New South Wales ... ... Aug. 6, 1892
363 Jones, John Arthur, Gijon, Asturias, Spain... ... ... April 8, 1893

		Date of Election and of Transfer.
364	KANDA, REIJI, c/o Mr. Takahira Kanda, 9, Awajicho-Nechome, Kanda, Tokio, Japan	A.M. Aug. 4, 1894 M. Nov. 24, 1894
365	KAY, ROBERT, South Tanfield Colliery, Stanley, R.S.O., Co. Durham	Aug. 4, 1894
366	KAYLL, A. C., Gosforth, Newcastle-upon-Tyne *(Member of Council)*	S. Oct. 7, 1876 M. Aug. 3, 1889
367	KAYSER, H. W. FERD, The Mount Bischoff Tin Mining Company, Waratah, Tasmania	Nov. 24, 1894
368	KELLETT, MATTHEW H., 5, Elm Street, South Moor, Chester-le-Street	S. April 11, 1891 M. Aug. 3, 1895
369	KELLETT, WILLIAM, Portland Bank, Southport	June 1, 1878
370	KENDALL, JOHN D., Foxhouses Road, Whitehaven ...	Oct. 3, 1874
371	KIRKBY, J. W., Kirkland, Leven, Fife	Feb. 1, 1873
372	KIRKUP, J. P., Burnhope, Lanchester	April 11, 1891
373	KIRKUP, PHILIP, Cornsay Colliery Office, Esh, near Durham	S. Mar. 2, 1878 A.M. Aug. 7, 1886 M. Aug. 3, 1889
374	KIRTON, HUGH, Kimblesworth Colliery, Chester-le-Street ...	S. April 7, 1877 A.M. Aug. 1, 1885 M. June 8, 1889
375*	KNOWLES, ROBERT, Ednaston Lodge, near Derby	April 10, 1886
376	KONDO, R., 7, Setomoncho, Nihonbashi, Tokio, Japan ...	June 21, 1894
377	LALOR, JOHN O'GORMAN, P.O. Box 357, Johannesburg, Transvaal	April 8, 1893
378	LAMB, R., Troughton House, Cleator Moor, *via* Carnforth ..	Sept. 2, 1865
379	LAMB, R. O., West Denton, Newcastle-upon-Tyne	Aug. 2, 1866
380	LANCASTER, JOHN, Ashlawn, Rugby	Mar. 2, 1865
381	LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
382	LANDALE, A., Comely Park Place, Dunfermline	Dec. 2, 1858
383*	LAPORTE, H., 57, Rue de la Concorde, Brussels	May 5, 1877
384	LAVERICK, JOHN WALES, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham	A.M. Dec. 9, 1882 M. Aug. 3, 1889
385	LAVERICK, ROBT., West Rainton, Fence Houses	Sept. 2, 1876
386	LAWRENCE, H., Grange Iron Works, Durham *(Member of Council)*	Aug. 1, 1868
387	LAWRENCE, H. L., c/o Dr. Magin, P.O. Box 733, Johannesburg, Transvaal	April 8, 1893
388	LAWS, W. G., Town Hall, Newcastle-upon-Tyne	Oct. 2, 1880
389	LEACH, C. C., Seghill Colliery, Northumberland *(Member of Council)*	S. Mar. 7, 1874 A.M. Aug. 6, 1881 M. Aug. 4, 1883
390	LEBOUR, G. A., Durham College of Science, Newcastle-upon-Tyne	Feb. 1, 1873
391	LECK, WM., H.M. Inspector of Mines, Cleator Moor, Cumberland	Nov. 24, 1894
392	LECKIE, ROBERT G., Londonderry Iron Co., Limited, Londonderry, Nova Scotia	Dec. 9, 1893
393	LEE, J. W. R., 70, St. Helen's Gardens, North Kensington, London, W.	Aug. 5, 1893

		Date of Election and of Transfer.
394	Lewis, H. R., 7, Drapers' Gardens, London, E.C.	April 14, 1894
395	Lewis, Sir William Thomas, Mardy, Aberdare	Sept. 3, 1864
396	Liddell, J. M., 3, Victoria Villas, Newcastle-upon-Tyne ...	S. Mar. 6, 1875
		A.M. Aug. 6, 1881
		M. June 8, 1889
397	Liebert, R. A. D., P.O. Box 357, Johannesburg, Transvaal	April 8, 1893
398	Linday, George, Blackett Colliery, Haltwhistle	June 10, 1893
399	Linday, James, Bishop Auckland	Aug. 6, 1892
400	Lindop, A. B., Blackball, *via* Greymouth, New Zealand ...	Dec. 9, 1893
401	Linsley, R., Cramlington Colliery, Northumberland ...	July 2, 1872
402	Lishman, R. R., Durham Main Colliery, Durham	S. June 9, 1883
		M. Aug. 1, 1891
403	Lishman, T., Hetton Colliery, Hetton-le-Hole, R.S.O. ...	S. Nov. 5, 1870
		M. Aug. 3, 1872
404	Lishman, Wm., Holly House, Witton-le-Wear	April 1, 1858
405	Lishman, Wm., Thornhill Park, Sunderland	Mar. 7, 1861
406	Lishman, W. Ernest, Bunker Hill, Fence Houses	June 10, 1893
407	Lisle, J., The Ottos Kopje Diamond Mines, Limited, Ottos Kopje Chambers, P.O. Box 381, Kimberley, South Africa	S. July 2, 1872
		A.M. Aug. 3, 1878
		M. June 8, 1889
408	Little, Gilbert, 3 and 4, Lime Street Square, London ...	April 27, 1895
409	Liveing, E. H., 52, Queen Anne Street, Cavendish Square, London, W.	S. Sept. 1, 1877
		A.M. Aug. 2, 1884
		M. Aug. 3, 1889
410	Livesey, C., Bradford Colliery, near Manchester	Aug. 3, 1865
411	Livesey, T., Bradford Colliery, near Manchester	S. Nov. 7, 1874
		M. Aug. 7, 1875
412	Llewellin, David Morgan, Glanwern Offices, Pontypool	May 14, 1881
413	Lloyd, G. Hamilton, Dolgerddon, Rhayader, Radnorshire. Transactions, etc., to 9, Lower Belgrave Street, London, S.W.	Dec. 9, 1893
414	Logan, William, Langley Park Colliery, Durham	Oct. 5, 1867
415	Longbotham, R. H., Westgate, Wakefield	April 8, 1893
416	Longridge, Jethro, Coxlodge Colliery, Newcastle-upon-Tyne	Dec. 14, 1889
417	Louis, D. A., 77, Shirland Gardens, London, W.	April 8, 1893
418	Lovely, W. H. C., Coolgardie, Western Australia	June 8, 1895
419	Lowdon, Thos., Hamsteels, near Durham	Dec. 14, 1889
420	Lupton, A., 6, De Grey Road, Leeds	Nov. 6, 1869
421	MacArthur, John S., 108A, Hope Street, Glasgow	April 8, 1893
422	MacCabe, H. O., Russell Vale, Wollongong, New South Wales	S. Sept. 7, 1878
		A.M. Aug. 7, 1880
		M. Aug. 3, 1889
423	McCarthy, E. T., c/o Col. Pigott, Archer Lodge, Charles Road, St. Leonards-on-the-Sea	A.M. Oct. 8, 1887
		M. Aug. 3, 1889
424	McCreath, J., 203, St. Vincent Street, Glasgow	Mar. 5, 1870
425	McCulloch, David, Beech Grove, Kilmarnock, N.B. ...	Dec. 4, 1875
426	McGeachie, Duncan, Waratah Colliery, Charlestown, near Newcastle, New South Wales	Nov. 24, 1894

		Date of Election and of Transfer.
427	McLaren, B., Jun., The Tower, Bedlington	S. Dec. 8, 1883
		A.M. Aug. 4, 1888
		M. Aug. 3, 1889
428	McMurtrie, George Edwin James, Foxes Bridge Colliery, Cinderford, Gloucestershire	S. Aug. 2, 1884
		M. Dec. 12, 1891
429	McMurtrie, J., Radstock Colliery, Bath	Nov. 7, 1863
430	Maddison, Thos. R., Dirtcar House, near Wakefield ...	S. Mar. 3, 1877
		A.M. Aug. 6, 1881
		M. June 8, 1889
431	Maddison, W. H. F., The Lindens, Darlington	June 14, 1890
432	Maling, C. T., Ellison Place, Newcastle-upon-Tyne ...	Oct. 5, 1872
433	Mammatt, J. E., St. Andrew's Chambers, Leeds	Aug. 3, 1865
434	Markham, G. E., Coundon, Bishop Auckland	S. Dec. 4, 1875
		A.M. Aug. 7, 1880
		M. June 8, 1889
435	Marley, J. W., Thornfield, Darlington	S. Aug. 1, 1868
		M. Aug. 2, 1873
436	Marten, E. B., Pedmore, near Stourbridge	July 2, 1872
437	Martin, C. W., Newbottle Colliery Offices, Fence Houses...	Aug. 6, 1892
438	Mathieson, Alexander, Hetton Colliery, Carrington, near Newcastle, New South Wales	Nov. 5, 1892
439	Matthew, Wm., 10, Jackson's Lane, Calcutta, India ...	June 21, 1894
440	Matthews, D. H. F., H.M. Inspector of Mines, Highfield, Kilmorey Park, Chester	Nov. 24, 1894
441	Matthews, J., Messrs. R. and W. Hawthorn, Newcastle-upon-Tyne	A.M. April 11, 1885
		M. Aug. 3, 1889
442	Matthews, R. F., Harehope Hall, Alnwick	Mar. 5, 1857
443	Mawson, R. Bryham, Brick House, Westleigh, near Manchester	June 11, 1892
444	May, G., Harton Colliery Offices, near South Shields (Vice-President, *Member of Council*)	Mar. 6, 1862
445	Meldrum, J. J., Atlantic Works, City Road, Manchester	Nov. 24, 1894
446	Merivale, J. H., Togston Hall, Acklington, Northumberland *(Member of Council)*	May 5, 1877
447*	Merivale, W., General Manager, Barbados Railway, Barbados	A.M. Mar. 5, 1881
		M. Aug. 3, 1889
448	Merritt, W. Hamilton, 485, Huron Street, Toronto, Ontario, Canada	Oct. 14, 1893
449	Metcalf, A. T., The Cloisters, Maritzburg, South Africa...	June 21, 1894
450	Meysey-Thompson, A. H., Sun Foundry, Leeds	A.M. April 3, 1889
		M. Aug. 3, 1889
451	Middleton, Robert, Sheep Scar Foundry, Leeds	Aug. 1, 1891
452	Miller, James, The Mexican Gold and Silver Recovery Company, P.O. Box 121, Mexico City, Republic of Mexico	Aug. 4, 1894
453*	Miller, N.	A.M. Oct. 5, 1878
		M. Aug. 3, 1889
454	Mitchell, Chas., Jesmond, Newcastle-upon-Tyne	April 11, 1874
455	Mitchell, Clayton E. J., West Highlands, Winchester ...	Nov. 5, 1892
456	Mitchinson, R., Pontop Colliery, Annfield Plain, R.S.O., Co. Durham	Feb. 4, 1865

		Date of Election and of Transfer.
457	Mitton, A. Dury, Marlpool House, near Derby	Aug. 6, 1892
458	Monkhouse, Jos., Gilcrux, Carlisle	June 4, 1863
459	Moore, R. T., 156, St. Vincent Street, Glasgow	Oct. 8, 1892
460	Moore, R. W., Somerset House, Whitehaven	S. Nov. 5, 1870
		M. Aug. 4, 1877
461	Moore, William, Loftus Mines, Loftus-in-Cleveland, R.S.O.	A.M. Nov. 19, 1881
		M. Aug. 3, 1889
462	Morison, John, Cramlington House, Northumberland	A.M. Dec. 4, 1880
	(Member of Council)	M. Aug. 3, 1889
463	Morris, Wm., Waldridge Colliery, Chester-le-Street ...	Oct. 8, 1892
464*	Morton, H. J., 2, Westbourne Villas, South Cliff, Scarborough	Dec. 5, 1856
465	Moses, Wm., De Beers Consolidated Mines, Limited, Kimberley, South Africa...	June 21, 1894
466	Mountain, William C., Forth Banks, Newcastle-upon-Tyne	April 9, 1892
467	Mulholland, M. L., West Cornforth, R.S.O., Co. Durham	A.M. Dec. 11, 1886
		M. Aug. 3, 1889
468	Mundle, Arthur, Bank Chambers, 24, Grainger Street	S. June 5, 1875
	West, Newcastle-upon-Tyne	M. Aug. 4, 1877
469	Murray, John, Raneegunge Coal Association, Limited,	
	Giridih, India	Dec. 8, 1894
470	Murton, Chas. J., Delaval Benwell Colliery, Newcastle-	S. Mar. 6, 1880
	upon-Tyne	A.M. Aug. 3, 1887
		M. Aug. 3, 1889
471*	Nasse, Rudolph, Geheimerbergrat, Dörnsbergstrasse, 6, Berlin, W., Germany	Sept. 4, 1869
472	Nevin, John, Littlemoor, Mirfield, Normanton	S. May 2, 1868
		M. Aug. 5, 1871
473	Newbigin, H. Thornton, Ranen Iron Ore Company, Fuglestrand, Hemnœs, Norway	Oct. 13, 1894
474	Newton, James, Whitehaven Colliery, Whitehaven ...	Nov. 5, 1892
475	Nichol, Wm., De Beers Mine, Kimberley, South Africa ...	A.M. Oct. 9, 1886
		M. Aug. 3, 1889
476	Nicholson, J. Cook, Collingwood Street, Newcastle-upon-Tyne	Feb. 10, 1894
477	Nicholson, J. H., Cowpen Colliery Office, Blyth	S. Oct. 1, 1881
		A. Aug. 3, 1889
		M. April 8, 1893
478	Nicholson, Marshall, Middleton Hall, Leeds	Nov. 7, 1863
479	Nixon, Ralph	Oct. 14, 1893
480	Noble, Thomas George, Sacriston Colliery, Durham ...	A. Feb. 13, 1892
		M. June 8, 1895
481	North, F. W., 18, St. Swithin's Lane, London, E.C. ...	Oct. 6, 1864
482	Oates, Robert J. W., Great Eastern Hotel, Calcutta, India	S. Feb. 10, 1883
		A.M. Aug. 1, 1891
		M. Dec. 12, 1891
483	Ogilvie, A. Graeme, 8, Grove End Road, St. John's Wood, London	Mar. 3, 1877
484	Oldham, George, 25, Western Hill, Durham...	Nov. 5, 1892

		Date of Election and of Transfer.
485	OLIVER, SEPTIMUS, Tyne House, Tynemouth	Nov. 24, 1894
486	ORNSBY, R. E., Seaton Delaval Colliery, Newcastle-upon-Tyne	S. Mar. 6, 1875 A.M. Aug. 4, 1883 M. June 8, 1889
487	OSWALD, R. P. W., 10, Rose Bank, Whitehaven	Aug. 4, 1894
488	PALMER, A. S., 3, Victoria Square, Newcastle-upon-Tyne ...	July 2, 1872
489	PALMER, SIR CHAS. MARK, Bart., Quay, Newcastle-upon-Tyne	Nov. 5, 1852
490	PALMER, CLAUDE B., Wardley Hall, near Newcastle-upon-Tyne	A.M. Nov. 5, 1892 M. June 8, 1895
491	PALMER, HENRY, East Howle Colliery, near Ferryhill *(Member of Council)*	S. Nov. 2, 1878 A.M. Aug. 4, 1883 M. Aug. 3, 1889
492	PAMELY, C., Wye Cliffe House, Welsh Street, Chepstow ...	S. Sept. 5, 1868 M. Aug. 5, 1877
493	PANTON, F. S., Silksworth Colliery, Sunderland	S. Oct. 5, 1867 M. Aug. 4, 1874
494	PARRINGTON, M. W., Wearmouth Colliery, Sunderland ...	S. Dec. 1, 1864 M. Aug. 6, 1870
495	PARSONS, HON. CHARLES ALGERNON, Holeyn Hall, Wylam-upon-Tyne	A.M. June 12, 1886 M. Aug. 3, 1889
496	PEAKE, R. C., Cumberland House, Redbourn, Herts. ...	S. Feb. 7, 1880 A.M. Aug. 7, 1886 M. Aug. 3, 1889
497	PEASE, SIR J. W., Bart., Hutton Hall, Guisbrough, Yorkshire	Mar. 5, 1857
498	PEEL, ROBERT, New Brancepeth Colliery, Durham	Aug. 6, 1892
499	PEILE, WILLIAM, Croft Hill, Moresby, Whitehaven ...	S. Oct. 1, 1863 M. Aug. 6, 1870
500	PICKUP, P. W., 71, Preston New Road, Blackburn ...	Feb. 6, 1875
501	PLUMMER, JOHN, H.M. Inspector of Mines, Bishop Auckland	June 8, 1889
502	POTTER, A. M., Aydon Grange, Corbridge-upon-Tyne *(Member of Council)*	S. Feb. 3, 1872 M. Aug. 5, 1876
503	POTTER, C. J., Heaton Hall, Newcastle-upon-Tyne	Oct. 3, 1874
504	POWER, F. DANVERS, c/o Messrs. Henderson and Macfarlane, 2, Bridge Street, Sydney, New South Wales	A.M. Aug. 4, 1894 M. Nov. 24, 1894
505	PRICE, S. R., c/o Messrs. Forster Brown and Rees, 12, Victoria Street, Westminster, London, S.W.	S. Nov. 3, 1877 A.M. Aug. 1, 1885 M. Aug. 3, 1889
506	PRICE-WILLIAMS, R., Victoria Mansions, 32, Victoria Street, London, S.W.	Feb. 10, 1894
507	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
508	PRINGLE, THOMAS, Tanfield Lea Colliery, Lintz Green ...	Aug. 6, 1892
509*	PRIOR, EDWARD G., Victoria, British Columbia. Transactions, etc., to Wm. McGregor, Manager, Vancouver Coal Company, Nanaimo, British Columbia	Feb. 7, 1880
510	PRITCHETT, C. W., Jun., Apartado 84, Pachuca, Estado Hidalgo, Mexico	Dec. 9, 1893
511	PROUT, JAMES, 16, Claremont Road, Redruth, Cornwall ...	Feb. 10, 1894
512	PROUST, RENE, Mammoth Hydraulic Sluicing Company, Matakitaki River, Central Buller, New Zealand ...	June 21, 1894

Date of Election and of Transfer.

513 Quirk, J. S., St. Helens Lead Smelting Works, St. Helens, Lancashire ... ... June 10, 1893

514 Ramsay, J. A., Sherburn and Littletown Collieries, near Durham ... ... Mar. 6, 1869
515 Ramsay, Wm., Tursdale, Co. Durham ... ... Sept. 11, 1875
516 Randolph, Beverley S., Frostburg, Maryland, U.S.A. ... Aug. 4, 1894
517 Redmayne, R. A. S., Seaton Delaval Colliery, Newcastle-upon-Tyne ... ... S. Dec. 13, 1884 M. Dec. 12, 1891
518 Redwood, Boverton, Glenwathen, Church End, Finchley, London, N. ... ... June 21, 1894
519 Reid, Andrew, Newcastle-upon-Tyne ... ... April 2, 1870
520 Reid, A. H., P.O. Box 746, Johannesburg, Transvaal ... June 21, 1894
521 Reid, Francis, 13, Railway Arches, Westgate Road, Newcastle-upon-Tyne ... ... April 9, 1892
522 Reid, P. S., 20, John Street, Adelphi, London, W.C. ... Dec. 10, 1892
523 Renwick, T. C., Manor House, Lumley Park, Fence Houses April 14, 1894
524 Rhodes, C. E., Car House, Rotherham ... ... Aug. 4, 1883
525 Rhodes, F. B. F., Superintendent of the National Smelting and Refining Co., South Chicago, Illinois, U.S.A. ... Feb. 10, 1894
526 Rich, William, Minas de Rio Tinto, Provincia de Huelva, Spain ... ... A.M. June 9, 1888 M. Aug. 3, 1889
527 Richardson, H., Backworth Colliery, Newcastle-upon-Tyne ... ... Mar. 2, 1865
528 Richardson, Ralph, Whitburn Colliery, South Shields ... S. June 9, 1883 M. Aug. 1, 1891
529 Richardson, Robert, Blaydon Main Colliery, Blaydon-upon-Tyne ... ... A. Feb. 8, 1890 M. Aug. 3, 1895
530 Ridley, G., 16, Dean Street, Newcastle-upon-Tyne... ... S. Feb. 4, 1865 M. Aug. 1, 1868
531 Ridley, N. B., 58, Collingwood Street, Newcastle-upon-Tyne ... ... June 8, 1895
532 Ridyard, J., Bridgewater Offices, Walkden, near Bolton-le-Moors, Lancashire ... ... Nov. 7, 1874
533 Ritson, U. A., 15, Queen Street, Newcastle-upon Tyne ... Oct. 7, 1871
534 Robertson, D. A. W., Metropolitan Colliery, Helensburgh, near Sydney, New South Wales ... ... Aug. 6, 1892
535*Robertson, J. R. M., Linton, Mitson's Point, Sydney, New South Wales ... ... Aug. 2, 1890
536 Robertson, W., 123, St. Vincent Street, Glasgow ... ... Mar. 5, 1870
537 Robinson, C., P.O. Box 1244, Johannesburg, Transvaal ... Dec. 9, 1893
538 Robinson, G. C., Brereton and Hayes Colliery, Rugeley, Staffordshire ... ... Nov. 5, 187)
539 Robinson, J. B., Hedley Hill Colliery, Waterhouses ... Aug. 5, 1893
540 Robinson, John Thomas, South Medomsley Colliery, Dipton, R.S.O. ... ... Feb. 13, 1892
541 Robinson, R., Howlish Hall, near Bishop Auckland *(Member of Council)* ... ... Feb. 1, 1868
542 Robson, J. S., Butterknowle Colliery, *via* Darlington ... May 15, 1862
543 Robson, T. O., Chowdene Cottage, Low Fell *(Member of Council)* ... ... S. Sept. 11, 1875 A.M. Aug. 2, 1884 M. June 8, 1889

Date of Election and of Transfer.

544 ROCHESTER, WILLIAM, River View, Blaydon-upon-Tyne ... Dec. 13, 1891

545 RONALDSON, J. H., Mount Kembla Colliery, Wollongong, New South Wales ... ... Aug. 6, 1892

546 RONTREE, THOMAS, 12, Northcote Street, South Shields ... A. Aug. 2, 1890
M. Aug. 3, 1895

547 ROSCAMP, J., Shilbottle Colliery, Lesbury, R.S.O., Northumberland ... ... Feb. 2, 1867

548 ROSS, ALEXANDER, Wallsend Collieries, Newcastle, New South Wales ... ... Dec. 8, 1894

549 ROSS, HUGH, Croxdale Colliery Office, Durham ... ... Aug. 6, 1892

550 ROSS, J. A. G., Newcastle-upon-Tyne ... ... July 2, 1872

551 ROSSER, W., Rhydyrhelig, Sketty, Swansea ... ... Aug. 6, 1857

552 ROTHWELL, R. P., 253, Broadway (P.O. Box 1833), New York, U.S.A. ... ... Mar. 5, 1870

553 ROUTLEDGE, Jos., Greenbank, Chester-le-Street ... ... Sept. 11, 1875

554 ROUTLEDGE, W. H., The Rhyd, Tredegar, Monmouth, South Wales ... ... S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

555 ROWAN, JAMES, Inspector of Collieries, Wollongong, New South Wales ... ... Aug. 6, 1892

556 ROWE, DANIEL, Ferreira Gold Mining Company, Limited, Johannesburg, Transvaal ... ... June 21, 1894

557 ROWLEY, WALTER, 20, Park Row, Leeds ... ... Aug. 5, 1893

558 RUSSELL, JAMES, Ukalunda, *via* Bowen, Queensland ... Oct. 13, 1894

559 RUSSELL, ROBERT, Coltness Iron Works, Newmains, N.B. ... Aug. 3, 1878

560 RUTHERFORD, W., South Derwent Colliery, Annfield Plain, Lintz Green ... ... Oct. 3, 1874

561*SAISE, WALTER, Manager, E.I.R. Collieries, Giridih, Bengal, India ... ... A.M. Nov. 3, 1877
M. Aug. 3, 1889

562 SAM, T. B. F., c/o Messrs. F. and A. Swanzy, Cape Coast Castle, West Africa ... ... Aug. 5, 1893

563 SAM, W. E., Jun., c/o Messrs. F. and A. Swanzy, Cape Coast Castle, West Africa ... ... Nov. 24, 1894

564 SAMBORNE, JOHN STUKELY PALMER, Timsbury House, Bath Aug. 1, 1891

565 SANER, C. TAYLOR, Per Private Bag, Van Ryn Gold Mines Estate, Limited, Vlakfontein, Johannesburg, Transvaal Oct. 13, 1894

566*SAWYER, A. R., P.O. Box 2233, Johannesburg, Transvaal ... S. Dec. 6, 1873
A.M. Aug. 2, 1879
M. June 8, 1889

567 SCARTH, W. T., Raby Castle, Staindrop, Darlington ... April 4, 1868

568 SCHROLLER, WM., 13, Old Elvet, Durham ... ... Aug. 4, 1894

569 SCOTT, C. F., Grove Cottage, Leadgate, Co. Durham ... S. April 11, 1874
M. Aug. 4, 1877

570 SCOTT, ELGIN, Ropienka Oil Wells, Ropienka, Galicia, Austria Aug. 4, 1894

571 SCOTT, ERNEST, Close Works, Newcastle-upon-Tyne ... April 9, 1892

572 SCOTT, JOSEPH, Ngahire, *via* Greymouth, New Zealand ... Aug. 5, 1893

573 SCOTT, JOSEPH S., Trimdon Hall, Trimdon Grange, R.S.O. ... S. Nov. 19, 1881
M. April 9, 1892

574 SCOULAR, G., St. Bees, Cumberland ... ... July 2, 1872

		Date of Election and of Transfer.
575	Seccombe, Alfred F., Albaston, Gunnislake, Cornwall ...	Dec. 9, 1893
576	Selby, Atherton, Leigh, near Manchester	Oct. 13, 1883
577	Selkirk, John Gunsen, Dalton-in-Furness	April 8, 1893
578	Seymour, L. Irving, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Feb. 14, 1891
579	Shaw, F. George, c/o Bainbridge, Seymour, and Co., 13, St. Helen's Place, London, E.C.	June 10, 1893
580	Shaw, J. Leslie, Somerset House, Whitehaven	Oct. 8, 1892
581	Sheafer, A. Whitcomb, Pottsville, Pennsylvania, U.S.A.	Aug. 4, 1894
582	Shiel, John, Framwellgate Colliery, Co. Durham	May 6, 1871
583	Shipley, T., 26, Riversdale Terrace, Sunderland	A.M. Aug. 2, 1884
		M. Aug. 3, 1889
584	Shore, Wm. Martin, Kaitangata Railway and Coal Co.'s Collieries, Otago, New Zealand	A.M. April 13, 1889
		M. Aug. 3, 1889
585	Shotton, John, Ottoman Railway Co., Smyrna, Asia Minor	Oct. 14, 1893
586	Shute, C. A., Portland House, Eastbourne, Darlington ...	April 11, 1874
587	Sibold, C. W., Public Works Department, Soane Circle, Arrah, Bengal, India	Dec. 9, 1893
588	Simpson, C. L., Engine Works, Grosvenor Road, Pimlico, London...	April 8, 1893
589	Simpson, F. L. G., Mohpani Coal Mines, Gadawarra, C.P., India	A.M. Dec. 13, 1884
		M. Aug. 3, 1889
590	Simpson, F. R., Hedgefield House, Blaydon-upon-Tyne ...	S. Aug. 4, 1883
		M. Aug. 1, 1891
591	Simpson, J., Heworth Colliery, Felling, R.S.O., Co. Durham	S. Dec. 6, 1866
		M. Aug. 1, 1868
592	Simpson, J. B., Bradley Hall, Wylam-upon-Tyne (Past-President, *Member of Council*)	Oct. 4, 1860
593	Slinn, T., Plashetts Colliery, Falstone, Northumberland ...	July 2, 1872
594	Smart, A., De Beers Mine, Kimberley, South Africa ...	Feb. 10, 1894
595	Smith, Eustace, Newcastle-upon-Tyne	A.M. June 11, 1887
		M. Aug. 3, 1889
596*	Smith, R. Clifford, Ashford Hall, Bakewell	Dec. 5, 1874
597	Smith, T. E., Phœnix Foundry, Newgate Street, Newcastle-upon-Tyne	Dec. 5, 1874
598	Sopwith, A., Cannock Chase Collieries, near Walsall ...	Aug. 6, 1863
599	Southern, E. O., Ashington Colliery, near Morpeth ...	S. Dec. 5, 1874
		A.M. Aug. 1, 1885
		M. June 8, 1889
600	Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff	Aug. 3, 1865
601	Southworth, Thos., Hindley Green Collieries, near Wigan	May 2, 1874
602	Spargo, Edmund, 3, Cable Street, Liverpool	June 10, 1893
603	Sparkes, J. S., Highview House, Pucklechurch, Gloucestershire	April 9, 1892
604	Spence, R. F., Backworth, R.S.O., Northumberland ...	S. Nov. 2, 1878
		A.M. Aug. 2, 1884
		M. Aug. 4, 1889
605	Spencer, Francis H., Robinson Gold Mining Co., Witwatersrand, Transvaal	Dec. 13, 1890

		Date of Election and of Transfer.
606	SPENCER, JOHN, Westgate Road, Newcastle-upon-Tyne ...	Dec. 4, 1869
607	SPENCER, JOHN W., Newburn, near Newcastle-upon-Tyne...	May 4, 1878
608	SPENCER, T., Ryton, Newcastle-upon-Tyne	Dec. 6, 1866
609	SPOTSWOOD, G. A., 46, Clarence Street, Kingston, Ontario, Canada...	Oct. 13, 1894
610	SQUIRE, J. B., 297, Clapham Road, London, S.W.	June 8, 1895
611	STANSFELD, HAROLD SINCLAIR, High Hazels Colliery, Darnall, Sheffield	A.M. Oct. 13, 1888 M. Aug. 3, 1889
612	STANTON, JOHN, 11 and 13, William Street, New York, U.S.A.	June 8, 1895
613	STANTON, PHILIP, Throckley Colliery, Newcastle-upon-Tyne	S. Dec. 8, 1888 A. Aug. 4, 1894 M. Aug. 3, 1895
614	STEAVENSON, A. L., Durham (PAST-PRESIDENT, *Member of Council)*	Dec. 6, 1855
615	STEAVENSON, C. H., Brotton Mines, Brotton, R.S.O., Yorkshire	S. April 14, 1883 A. Aug. 1, 1891 M. Aug. 3, 1895
616	STEPHENSON, G. R., Ben Braich, Tilehurst Road, Reading	Oct. 4, 1860
617	STEVENS, A. J., Uskside Ironworks, Newport, Monmouthshire	April 8, 1893
618	STEVENS, JAMES, 9, Fenchurch Avenue, London, E.C. ...	Feb. 14, 1885
619	STEWART, WM., Tillery Collieries, Abertillery, Monmouthshire	June 8, 1895
620	STOBART, F., Biddick Hall, Fence Houses *(Member of Council)*	S. Aug. 2, 1873 A.M. Aug. 5, 1882 M. June 8, 1889
621	STOBART, H. T., Wearmouth Colliery, Sunderland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
622	STOBART, W., Pepper Arden, Northallerton	July 12, 1872
623	STOBART, WM. RYDER, Etherley Lodge, Darlington ...	Oct. 11, 1890
624	STOBBS, J. T., Walker Colliery, Walker-upon-Tyne ...	Feb. 13, 1892
625	STOKER, ARTHUR P., Birtley, near Chester-le-Street ...	S. Oct. 6, 1877 A.M. Aug. 1, 1885 M. Aug. 3, 1889
626	STRAKER, J. H., Howden Dene, Corbridge-upon-Tyne ...	Oct. 3, 1874
627	STREATFIELD, HUGH S., Ryhope, near Sunderland	A.M. June 8, 1889 M. Aug. 3, 1889
628	STUART, DONALD M. D., Redland, Bristol	June 8, 1895
629	SULLIVAN, C. D., Bonang, Delegate, New South Wales ...	Feb. 9, 1895
630	SWALLOW, J., Catchgate, Annfield Plain, R.S.O., Co. Durham	May 2, 1874
631	SWALLOW, R. T., Simonside House, Simonside, South Shields	Feb. 5, 1863
632	SWAN, H. F., North Jesmond, Newcastle-upon-Tyne ...	Sept. 2, 1871
633	SWAN, J. G., Upsall Hall, near Middlesbrough	Sept. 2, 1871
634	SYKES, FRANK K., Springwell Villa, Bishop Auckland ...	S. Feb. 13, 1886 M. Feb. 10, 1894

		Date of Election and of Transfer.
635	TATE, SIMON, Trimdon Grange Colliery, Co. Durham *(Member of Council)*	Sept. 11, 1875
636	TAYLOR, HUGH, East Holywell Office, Quay, Newcastle-upon-Tyne	Sept. 5, 1856
637	TAYLOR, T., Quay, Newcastle-upon-Tyne	July 2, 1872
638	TAYLOR-SMITH, THOMAS, Broadwood Park, Lanchester ...	Aug. 2, 1866
639	TEASDALE, THOMAS, Middridge, *via* Heighington, R.S.O. ...	April 9, 1892
640	TELFORD, W. H., Hedley Hope Collieries, Tow Law, R.S.O., Co. Durham	S. Oct. 3, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
641	THOMAS, EDWARD, The Shieling, Auburn, Sydney, New South Wales	Aug. 4, 1894
642	THOMAS, J. J., Newnham Cottage, Kendal	June 21, 1894
643	THOMPSON, CHARLES LACY, Farlam Hall, Brampton Junction, Cumberland	A.M. Feb. 10, 1883 M. Aug. 3, 1889
644*	THOMPSON, F. A., Broad Street House, London, E.C. ...	Dec. 8, 1894
645	THOMPSON, R., Jun., 19, The Crescent, Gateshead-upon-Tyne	Sept. 7, 1867
646	THOMPSON, W., c/o Messrs. Alexander Matheson and Company, Coolgardie, Western Australia	Aug. 4, 1888
647	THOMSON, JOHN, Eston Mines, by Middlesbrough	April 7, 1877
648	THOMSON, Jos. F., Manvers Main Colliery, Rotherham ...	Feb. 6, 1875
649	TINKER, J. J., Hyde, Manchester	April 9, 1892
650	TODD, JOHN T., Bedford Lodge, Bishop Auckland	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
651	TONKIN, J. J., Linares, Provincia de Jaen, Spain	Oct. 14, 1893
652	TOUZEAU, E. M., Leadenhall Buildings, Leadenhall Street, London, E.C.	Aug. 6, 1892
653	TRELEASE, W. HENWOOD, Pesterena United Gold Mining Company, Limited, Pestarena, Vall Anzasca, Novara, Italy	April 8, 1893
654*	TYERS, JOHN E., Singareni Collieries, c/o The Hyderabad Deccan Company, Limited, Secunderabad, East India...	A.M. Dec. 10, 1877 M. Aug. 3, 1889
655	TYZACK, D., 71, Westgate Road, Newcastle-upon-Tyne ...	Feb. 14, 1874
656	VARTY, THOMAS, Skelton Park Mines, Skelton, R.S.O., Cleveland	Feb. 12, 1887
657	VAUGHAN, CEDRIC, Hodbarrow Iron Ore Mines, Millom, Cumberland	Dec. 10, 1892
658	VEASY, HARVEY C., Burrakar Coal Company, Limited, Barakar, Bengal, East India	June 21, 1894
659	VEZIN, HENRY A., P.O. Box 256, Denver, Colorado, U.S.A.	June 21, 1894
660	VITANOFF, GEO. N., Sophia, Bulgaria	A.M. April 22, 1882 M. Aug. 3, 1889
661	VIVIAN, JOHN, Vivian's Boring and Exploration Company, Limited, 42, Lowther Street, Whitehaven	Mar. 3, 1877
662	WADDLE, HUGH, Llanmore Iron Works, Llanelly, South Wales	Dec. 13, 1890
663	WADHAM, E., Millwood, Dalton-in-Furness	Dec. 7, 1867
664	WALES, H. T., Pontypridd, South Wales	Feb. 11, 1893

		Date of Election and of Transfer.
665	WALKER, J. S., Pagefield Iron Works, Wigan, Lancashire	Dec. 4, 1869
666	WALKER, W., Hawthorns, Saltburn-by-the-Sea	Mar. 5, 1870
667	WALKER, WM., Jun., H.M. Inspector of Mines, Durham ...	Aug. 3, 1889
668	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
669	WALL, HENRY, Rowbottom Square, Wallgate, Wigan ...	June 8, 1895
670	WALLACE, HENRY, Trench Hall, Gateshead-upon-Tyne ...	Nov. 2, 1872
671	WALLAU, JACOB, Messrs. Black, Hawthorn, and Co., Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
672	WALLWORK, JESSE, Haydock Collieries, near St. Helen's, Lancashire	Feb. 9, 1895
673	WALSH, G. PATON, 564, Heirengracht, Amsterdam, Holland	Nov. 24, 1894
674	WALTON, J. COULTHARD, Writhlington Colliery, Radstock, *via* Bath	S. Nov. 7, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
675	WARD, A. H., c/o Bengal Coal Company, Limited, Calcutta, India	April 14, 1894
676	WARD, H., Rodbaston Hall, near Penkridge, Stafford ...	Mar. 6, 1862
677*	WARD, T. H., Giridih, E.I. Railway, Bengal, India ...	A.M. Aug. 5, 1882 M. Aug. 3, 1889
678	WATKYN-THOMAS, W., Mineral Office, Cockermouth Castle	A.M. Feb. 10, 1883 M. Aug. 3, 1889
679	WATSON, EDWARD, 19, Bloomfield Terrace, Gateshead-upon-Tyne	S. Feb. 13, 1892 M. Aug. 4, 1894
680	WATSON, THOMAS, Trimdon Colliery, Trimdon Grange ...	Oct. 11, 1890
681	WEBSTER, H. INGHAM, Morton House, Fence Houses ...	A.M. April 14, 1883 M. Aug. 3, 1889
682	WEEKS, J. G., Bedlington, R.S.O., Northumberland (VICE-PRESIDENT, *Member of Council*)...	Feb. 4, 1865
683	WEEKS, R. L., Willington, Co. Durham	A.M. June 10, 1882 M. Aug. 3, 1889
684	WESTERN, C. R., Broadway Chambers, Westminster, London, S.W....	June 10, 1893
685	WHITE, C. E., Wellington Terrace, South Shields	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. Aug. 3, 1889
686	WHITE, H., Walker Colliery, Newcastle-upon-Tyne ...	S. Mar. 2, 1867 M. Aug. 5, 1871
687	WHITE, J. F., Wakefield	S. July 2, 1872 M. Aug. 2, 1873
688	WHITE, J. W. H., Bedford House, Roundhay, Leeds ...	Sept. 2, 1876
689	WHITEHEAD, JAS., Brindle Lodge, near Preston, Lancashire	Dec. 4, 1875
690	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
691	WHITTEM, THOS. S., Wyken Colliery, near Coventry ...	Dec. 5, 1874
692	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington	Dec. 5, 1868
693	WIGHT, EDWD. S., Kiripaka, near Auckland, New Zealand	A.M. Dec. 12, 1885 M. Aug. 3, 1889
694	WIGHT, W. H., Cowpen Colliery, Blyth	Feb. 3, 1877
695	WILLIAMS, ERNEST, P.O. Box 965, Bittelheim Buildings, Simmonds Street, Johannesburg, Transvaal	Oct. 10, 1891
696	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton	Nov. 5, 1852
697	WILSON, P. O., Klerksdorp, South Africa	Dec. 9, 1893

		Date of Election and of Transfer.
698	WILSON, LLOYD, Flimby Colliery, Maryport	Jan. 19, 1895
699	WILSON, W. B., Thornley Colliery, by Trimdon Grange, Co. Durham	Feb. 6, 1869
700	WINCHELL, HORACE V., 1306, S.E. Seventh Street, Minneapolis, Minn., U.S.A.	Nov. 24, 1894
701	WINSTANLEY, ROBERT, 28, Deansgate, Manchester	Sept. 7, 1878
702	WINTER, T. B., Grey Street, Newcastle-upon-Tyne... ...	Oct. 7, 1871
703	WOOD, C. L., Freeland, Forgandenny, Perthshire	Aug. 3, 1854
704	WOOD, ERNEST SEYMOUR, South Hetton, Sunderland ...	Oct. 10, 1891
705	WOOD, JOHN, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham ..	S. June 8, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
706	WOOD, LINDSAY, The Hermitage, Chester-le-Street (PAST-PRESIDENT, *Member of Council)*	Oct. 1, 1857
707	WOOD, THOMAS, North Hetton Colliery Office, Moorsley, Hetton-le-Hole, R.S.O.	S. Sept. 3, 1870 M. Aug. 5, 1871
708	WOOD, W. H., Coxhoe Hall, Coxhoe, Co. Durham *(Member of Council)*	Aug. 6, 1857
709	WOOD, W. O., South Hetton, Sunderland (VICE-PRESIDENT, *Member of Council)*	Nov. 7, 1863
710	WOODBURNE, T. J., De Beers Consolidated Mining Company, Limited, Kimberley, South Africa	Feb. 10, 1894
711	WOOLCOCK, J. H., 49, Lowther Street, Whitehaven ...	June 10, 1893
712	WORMALD, C. F., Mayfield Villa, Saltwell, Gateshead-upon-Tyne	A.M. Dec. 8, 1883 M. Aug. 3, 1889
713	WRIGHTSON, T., Stockton-upon-Tees	Sept. 13, 1873
714	YEOMAN, THOMAS P., Bengal Coal Company, Limited, Koodeah Collieries, Giridih, E.I.R., Bengal, India ...	S. Feb. 14, 1885 A. Aug. 4, 1894 M. Oct. 13, 1894
715	YOUNG, JOHN A., 7, Tyne Vale Terrace, Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
716	YOUNG, JOHN HUNTLEY, Wearmouth Colliery, Sunderland	June 21, 1894
717	ZUMBULOGLON, G. C., Mahmoudie-Han, Stamboul, Turkey	S. Feb. 14, 1891 A. Aug. 4, 1894 M. Aug. 3, 1895

ASSOCIATE MEMBERS.

Marked * have paid life composition.

		Date of Election and of Transfer.
1	ALLHUSEN, ALFRED, Musgrave House, Gateshead-upon-Tyne ...	Dec. 10, 1892
2	ARMSTRONG, J. H., St. Nicholas' Chambers, Newcastle-upon-Tyne	Aug. 1, 1885
3	ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-upon-Tyne ...	Feb. 10, 1883
4	ATKINSON, G. B., Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne	Nov. 5, 1892
5	AUDUS, T., Mineral Traffic Manager, North Eastern Railway, Newcastle-upon-Tyne	Aug. 7, 1880

Date of Election and of Transfer.

6 Bell, B. T. A., Secretary of the General Mining Association of the Province of Quebec, Ottawa, Canada ... ... Aug. 6, 1892
7*Bell, Thos. Hugh, Middlesbrough-upon-Tees ... ... Dec. 9, 1882
8 Beneké, G., 70, Gracechurch Street, London, E.C. ... ... Feb. 9, 1895
9 Bigge, Edward Ellison, General Mining Association, Blomfield House, London Wall, London, E.C. Transactions, etc., to R. H. Brown, Sydney Mines, Cape Breton, Nova Scotia ... Aug. 1, 1891
10 Blenkiron, J. Ernest, The Residency, Zomba, British Central Africa ... ... Feb. 11, 1893
11 Blue, Archibald, Bureau of Mines, Toronto, Ontario, Canada... Feb. 10, 1894
12 Burdon, A. E., Hartford House, Cramlington, Northumberland Feb. 10, 1883

13 Capell, Rev. G. M., Passenham Rectory, Stony Stratford ... Oct. 8, 1892
14 Carr, Arthur D., Whickham Rectory, Whickham, R.S.O., Co. Durham ... ... Aug. 4, 1894
15*Carr, William Cochran, Lower Condercum, Newcastle-upon-Tyne ... ... Oct. 11, 1890
16 Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses ... June 1, 1878
17 Cockburn, W. C., 1, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... Oct. 8, 1887
18 Cooper, R. W., Newcastle-upon-Tyne ... ... Sept. 4, 1880

19 Davies, Henry, Treharris, R.S.O., South Wales .. .. Dec. 9, 1893
20 Dodds, A. P., 13, Dean Street, Newcastle-upon-Tyne ... ... Nov. 5, 1892
21 Duncan, G. T., 110, Dilston Road, Newcastle-upon-Tyne .. Aug. 5, 1893

22 East, J. G., 26, Side, Newcastle-upon-Tyne ... ... Feb. 10, 1894
23 Eccles, Edward, King Street, Newcastle-upon-Tyne ... ... Oct. 13, 1894
24 Edwards, F. H., Forth House, Bewick Street, Newcastle-upon-Tyne ... ... June 11, 1887
25 Elliot, Sir G. W., Bart., 16, Great George Street, Westminster, London, S.W. ... ... Jan. 19, 1895

26 Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S. ... Dec. 12, 1891

27 Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer) ... ... Aug. 4, 1888
28 Gwyn, A. E. W., 114A, Queen Victoria Street, London, E.C. ... Aug. 4, 1894

29 Hawkins, R. Spencer, Post Office, Salisbury, Mashonaland, South Africa ... ... April 14, 1894
30 Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent ... Dec. 2, 1858
31 Hedley, J. Hunt, John Street, Sunderland ... ... June 13, 1891
32 Henderson, C. W. C., The Riding, Hexham ... ... Dec. 9, 1882
33 Henzell, Robert, Close, Newcastle-upon-Tyne ... ... April 11, 1891
34 Hicks, James, Redruth, Cornwall ... ... April 14, 1894
35 Hopper, J. I., Wire Rope Works, Thornaby-on-Tees ... ... Dec. 8, 1888
36 Humble, Stephen, Jun., 9, Victoria Street, Westminster, London, S.W. ... ... Aug. 4, 1894
37 Humphreys-Davies, G., 8, Laurence Pountney Hill, Cannon Street, London, E.C. ... ... Oct. 8, 1892

Date of Election and of Transfer.

38 I'Anson, James, Fairfield House, Darlington ... ... Feb. 10, 1894
39 Irvine, Joseph R., Hendon Ropery, Sunderland ... ... Dec. 10, 1887

40 James, Henry M., Colliery Office, Whitehaven ... ... June 10, 1893
41*Joicey, James John, Sunningdale Park, Berks. ... ... Oct. 10, 1891

42 Krohn, H. A., 103, Cannon Street, London, E.C. ... ... Oct. 14, 1893

43 Larsen, A., The Carbonite Syndicate, Limited, 24, Queen Victoria Street, London, E.C. ... ... April 27, 1895

44 Middleton, R. J., Broad Street House, London, E.C. ... ... Oct. 13, 1894

45 Nason, Frank L., 5, Union Street, New Brunswick, New Jersey Aug. 4, 1894

46 Palmer, A. M., 14, Windsor Terrace, Newcastle-upon-Tyne ... Nov. 24, 1894
47 Patterson, Wm., 5, Hardwicke Terrace, Gateshead-upon-Tyne... Aug. 6, 1892
48*Pease, Arthur, Darlington. Transactions to be sent to the Librarian, Ed. Pease Free Library, Darlington ... ... Dec. 9, 1882
49 Perkins, Charles, Gallowhill Hall, Newcastle-upon-Tyne ... Aug. 6, 1892
50*Proctor, John H., 29, Side, Newcastle-upon-Tyne .. ... June 8, 1889

51 Richter, F., Osborne Villas, Newcastle-upon-Tyne ... ... Oct. 10, 1891
52 Ridley, J. Cartmell, 3, Summerhill Grove, Newcastle-upon-Tyne Feb. 11, 1893
53 Ridley, Sir Matthew W., Bart., Blagdon, Northumberland ... Feb. 10, 1883
54 Ritson, J. Ridley, Burnhope Collery, Lanchester... ... S. April 11, 1891
A.M. Aug. 3, 1895

55 Saunders, G. B., Messrs. Dawson, Saunders, and Todd, Maritime Buildings, Newcastle-upon-Tyne... ... ... Jan. 19, 1895
56 Scurfield, George J., Hurworth-upon-Tees, Darlington ... Dec. 9, 1882
57 Shaw, Saville, Durham College of Science, Newcastle-upon-Tyne ... ... April 13, 1889
58 Sheard, Robert, Caldervale Boiler Works, Wakefield ... ... Nov. 24, 1894
59 Smith, C. A., 20, Alexandra Place, Newcastle-upon-Tyne ... Dec. 8, 1894
60 Snowball, Francis John, Seaton Burn House, Dudley, Northumberland ... ... Dec. 12, 1891

61 Todd, James, Elvet Bridge, Durham... ... ... Aug. 6, 1892

62 Wall, G. Young, Halmote Court Office, New Exchequer Building, Durham... ... . Nov. 24, 1894
63 Walton, James, 23, Queen Street, Newcastle-upon-Tyne... ... Aug. 6, 1892
64 Watson, Arthur, Willington, Co. Durham ... ... Oct. 13, 1894
65 Weatherburn, John, 14, Stirling Terrace, Saltwell Lane, Gateshead-upon-Tyne ... ... Oct. 13, 1894
66 Wilson, Arthur P., Mansion House Chambers, Queen Victoria Street, London, E.C. ... ... Aug. 3, 1889
67 Woodward, Harry P., Perth, Western Australia ... ... June 10, 1893

ASSOCIATES.

		Date of Election and of Transfer.
1	Bainbridge, James, North Walbottle Colliery, Newcastle-upon-Tyne	June 10, 1893
2	Barrass, M., Tudhoe Colliery, Spennymoor	S. Feb. 9, 1884 A. Aug. 1, 1891
3	Battey, Thomas, Percy Terrace, Backworth Colliery ...	Oct. 13, 1894
4	Bell, John, Wardley Colliery, Newcastle-upon-Tyne ...	Feb. 8, 1890
5	Bell, W. Ralph, Wearmouth Colliery, Sunderland ...	Oct. 13, 1894
6	Berry, Thomas, 1, Middleton, Swalwell, R.S.O.	Nov. 5, 1892
7	Bolam, J. T., The View, Beamish, Chester-le-Street ...	Oct. 14, 1893
8	Bowes, Thomas, Pontop House, Annfield Plain, R.S.O. ...	Feb. 13, 1892
9	Brown, Robert O., Elswick Collieries, Newcastle-upon-Tyne	S. Oct. 8, 1892 A. Aug. 3, 1895
10	Chandley, Charles	S. Nov. 6, 1880 A. Aug. 3, 1889
11	Clark, Thomas, Dipton Colliery, Lintz Green Station ...	Oct. 11, 1890
12	Cockburn, Evan, Page Bank Colliery, *via* Spennymoor, Co. Durham	Aug. 5, 1893
13	Cowell, J. Stanley, Wearmouth Colliery, Sunderland ...	Oct. 13, 1894
14	Cowx, H. F., Fairfield House, Spennymoor	April 14, 1894
15	Crown, William, 29, Fifth Row, Ashington Colliery, Morpeth	April 14, 1894
16	Dormand, R. B., Waldridge Colliery, Chester-le-Street ...	Dec. 9, 1893
17	Draper, William, New Seaham Colliery, Sunderland ...	Dec. 14, 1889
18	Eltringham, G., Shiremoor Colliery, Newcastle-upon-Tyne	Dec. 8, 1894
19	Emerson, Robert, Tudhoe Colliery, Spennymoor	June 10, 1893
20	Fairs, John, Escomb Bridge, Bishop Auckland	Oct. 14, 1893
21	Fawcett, Edward, 27, Eastbourne Gardens, Walker-upon-Tyne	June 11, 1892
22	Foster, John William, 24, Silksworth Terrace, New Silksworth, Sunderland	Dec. 14, 1889
23	Fryar, John William, Seghill Colliery, Seghill, Northumberland	June 14, 1890
24	Griffiths, Ed., Brymbo Colliery, near Wrexham, North Wales	June 13, 1891
25	Harle, R. A., Hebburn Colliery, Hebburn, R.S.O. ...	April 14, 1894
26	Hedley, A. M., Medomsley, R.S.O., Co. Durham	Nov. 24, 1894
27	Henderson, William, Wheatley Hill Colliery, *via* Trimdon Grange	Aug. 5, 1893
28	Hepburn, Thomas, The Firs, Langley Park, Durham ...	Feb. 8, 1890
29	Hobson, Moses, Shildon, *via* Darlington	Aug. 5, 1893
30	Hodgson, E., Black Boy Colliery, Bishop Auckland ...	Aug. 6, 1892
31	Hunter, Christopher, Broomhill Colliery, Acklington, Northumberland	Dec. 10, 1892

	Date of Election and of Transfer.
32 James, Alexander A., Croxdale, near Durham	June 10, 1893
33 Johnson, William, Framwellgate Moor, Durham	Aug. 6, 1892
34 Linday, Robert, Bishop Auckland	Dec. 8, 1894
35 MacKinlay, Edward, East Stanley Colliery, Chester-le-Street	June 11, 1892
36 Mackintosh, Thos., Watt's Farm, Blyth	April 11, 1891
37 Mason, Benj., Burnopfield, R.S.O., Co. Durham	April 11, 1891
38 Miller, J. H., South Hetton, Sunderland	Dec. 8, 1894
39 Minto, George William, Chapel Row, Ouston, Chester-le-Street	Oct. 10, 1891
40 Mordy, Wm., Shelton Iron, Steel, and Coal Co., Limited, Stoke-upon-Trent	S. April 11, 1891 A. Aug. 3, 1895
41 Naisbit, John, No. 48, Tudhoe Colliery, Spennymoor ...	April 27, 1895
42 Nicholson, A. D., Lane Ends, Hetton-le-Hole, R.S.O., Co. Durham	S. June 13, 1885 A. Aug. 4, 1894
43 Parkinson, W., 6, Ivy Terrace, South Moor, Chester-le-Street	June 13, 1891
44 Patterson, Thomas, Craghead, Chester-le-Street	S. April 13, 1889 A. Aug, 4, 1894
45 Pedelty, Simon, Clara Vale, Ryton-upon-Tyne	Dec. 10, 1892
46 Pringle, Hy. Geo., Tanfield Lea Colliery, Lintz Green Station, Newcastle-upon-Tyne	S. Dec. 4, 1880 A. Aug. 4, 1894
47 Proctor, Thos., Ashington Colliery, Northumberland ...	Oct. 13, 1894
48 Ramsay, J. G., Page Bank Colliery, *via* Spennymoor, Co. Durham	Dec. 10, 1892
49 Ridley, Geo. D., Tudhoe Colliery, Spennymoor	Feb. 8, 1890
50 Rivers, John, Front Street, Tudhoe Colliery, Spennymoor	Feb. 9, 1895
51 Robson, William, Jun., Tow Law, R.S.O., Co. Durham ...	S. June 11, 1892 A. Aug. 3, 1895
52 Scott, E. Charlton, Rainton Colliery, Fence Houses ...	Oct. 8, 1892
53 Scott, Wm., Thornhill Collieries, near Dewsbury	S. Mar. 4, 1876 A. Aug. 6, 1892
54 Severs, William, Beamish View, *via* Chester-le-Street ...	Nov. 5, 1892
55 Shaw, John, Cramlington Colliery, Northumberland ...	April 11, 1891
56 Southern, John, Heworth Colliery, Newcastle-upon-Tyne	Dec. 14, 1889
57 Southern, Joseph C., Harraton Colliery, Washington Colliery, R.S.O., Co. Durham	Oct. 13, 1894
58 Spry, John, Murton Colliery, Durham...	Feb. 11, 1893
59 Stephenson, William, Garesfield Colliery, Lintz Green ...	Dec. 13, 1890
60 Stokoe, James, 7, North Street, Murton Colliery, *via* Sunderland	Nov. 24, 1894
61 Swallow, F. C., Simonside House, Simonside, South Shields	April 14, 1894
62 Thompson, John W., Backworth Colliery, Newcastle-upon-Tyne	June 10, 1893
63 Thompson, Joseph, 38, Church Street, Murton Colliery ...	April 8, 1893

		Date of Election and of Transfer.
64	WALLETT, T., 6, Moore's Buildings, Belmangate, Guisbro', Yorkshire	Feb. 10, 1894
65	WALTON, MATTHEW, Dearham Colliery, Carlisle	Dec. 14, 1889
66	WATSON, JOHN, 5, Lovaine Terrace, Low Fell	Dec. 12, 1891
67	WILSON, R. G., Pelton Colliery, Chester-le-Street	Aug. 6, 1892

STUDENTS.

		Date of Election.
1	ALLPORT, E. A., Colliery Office, Medomsley, R.S.O., Co. Durham	April 14, 1894
2	BOOTH, F. L., Ashington Colliery, Morpeth	Feb. 10, 1894
3	BURNE, CECIL A., Cornsay Colliery Office, near Durham... ...	Aug. 4, 1894
4	CLIFFORD, E. HERBERT, 24, Gledstanes Road, West Kensington, London, S.W.	Oct. 13, 1894
5	COWAN, H. D., Elswick Collieries, Newcastle-upon-Tyne ...	Jan. 19, 1895
6	DAVY, G. C. H., Manvers Main Colliery, Wath, near Rotherham	June 21, 1894
7	DENTON, JOHN, Netherseal Colliery, Burton-upon-Trent	June 21, 1894
8	DOUGLAS, DAVID, East Hetton Colliery, Coxhoe, R.S.O., Co. Durham	Aug. 1, 1891
9	FALCON, MICHAEL, 23. Cemetery Road, Treorchy, South Wales...	Oct. 13, 1894
10	FORSTER, J. H. B., Hetton Colliery, Hetton-le-Hole, R.S.O., Co. Durham	Nov. 24, 1894
11	GRIFFITH, N. M., c/o Broughton and Plas Power Coal Company, Limited, Wrexham...	Nov. 24, 1894
12	HARBIT, W. D., 32, High Street, Wallsend-upon-Tyne	Dec. 8, 1894
13	HETHERINGTON, J. R., c/o Mr. Burnley, Sisters Villas, Garforth Colliery, near Leeds	Aug. 4, 1894
14	IMESON, J. A., Wearmouth Colliery, Sunderland	Oct. 13, 1894
15	JONES, WM., Trimdon Grange Colliery, Trimdon Grange, R.S.O., Co. Durham...	Aug. 4, 1894
16	KING, FRED. Cramlington Village, Northumberland	Oct. 8, 1892
17	KIRKUP, AUSTIN, Murton Colliery, Sunderland	April 9, 1892
18	KIRKUP, FRED. O., The Riding, near Birtley	April 9, 1892
19	LISHMAN, T. A., The Tower, Durham	Nov. 24, 1894
20	LITTLEJOHN, ALBERT, Balgills Cottage, Broughty Ferry, Scotland	Nov. 24, 1894
21	MCGOWAN, ERNEST, Wearmouth Colliery, Sunderland	Oct. 13, 1894
22	MASCALL, W. H., c/o Mr. T. Dixon, Adelaide Colliery, near Shildon	Nov. 5, 1892
23	MIDDLETON, H. W., Trimdon Grange Colliery, Trimdon Grange, R.S.O., Co. Durham	Aug. 4, 1894

		Date of Election and of Transfer.
24	Neasham, Philip, Park View, Leadgate, Co. Durham	Nov. 24, 1894
25	Nisbet, Norman, Tantobie, Durham...	Nov. 24, 1894
26	Noble, Algernon, Broomhill Colliery, Acklington	Oct. 14, 1893
27	Peel, J. W., Coundon, Bishop Auckland	Aug. 4, 1894
28	Sample, J. B., South Tanfield Colliery, Stanley, R.S.O., Newcastle-upon-Tyne	Jan. 19, 1895
29	Sherwen, J. H., Marina Terrace, Hensingham, Whitehaven ..	Dec. 8, 1894
30	Simpson, Nelson Ashbridge, Bradley Hall, Wylam-upon-Tyne	Aug. 1, 1891
31	Stratton, H. S., Cramlington Collieries, Northumberland ...	Feb. 9, 1895
32	Swallow, W. A., Bushblades House, Lintz Green	Dec. 9, 1893
33	Wall, George, St. Helens Colliery, Bishop Auckland	Nov. 5, 1892
34	Waters, Edward, Throckley Colliery, Newcastle-upon-Tyne ...	April 14, 1894
35	Whitehead, John James, 85, Haworth Buildings, Cross Street, Manchester	Dec. 12, 1891
36	Willis, Henry Stevenson, Whickham, R.S.O., Co. Durham ...	Feb. 13, 1892

SUBSCRIBERS.

1 Owners of Ashington Colliery, Newcastle-upon-Tyne.
2 Birtley Iron Company (3), Birtley.
3 Bridgewater Trustees (3), Bridgewater Offices, Walkden, Bolton-le-Moors, Lancashire.
4 Marquess of Bute, Bute Estate Offices, Aberdare, South Wales.
5 Butterknowle Colliery Company, Darlington.
6 Cowpen Coal Company, Limited (2), F, King Street, Newcastle-upon-Tyne.
7 Earl of Durham (5), Lambton Offices, Fence Houses.
8 Elswick Coal Company, Limited, Newcastle-upon-Tyne.
9 Haswell Coal Company (2), Haswell Colliery, Haswell, *via* Sunderland.
10 Hetton Coal Company (5), Fence Houses.
11 Hutton Henry Coal Company, Limited, 7, Bondgate, Darlington.
12 Marquis of Londonderry (5), c/o V. W. Corbett, Esq., Londonderry Offices, Seaham Harbour.
13 Mills, John, and Sons, Limited, 23, Collingwood Street, Newcastle-upon-Tyne.
14 North Brancepeth Coal Company, Limited, Crown Street Chambers, Darlington.
15 Owners of North Hetton Colliery (3), Fence Houses.
16 Ryhope Coal Company (2), Ryhope Colliery, near Sunderland.
17 Owners of Seghill Colliery, Seghill, Northumberland.
18 Owners of South Hetton and Murton Collieries (2), 50, John Street, Sunderland.
19 Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne.
20 Owners of Throckley Colliery, Newcastle-upon-Tyne.
21 Owners of Victoria Garesfield Colliery, c/o George Peile, Esq., Shotley Bridge, Co. Durham.
22 Owners of Wearmouth Colliery (2), Sunderland.
23 Westport Coal Company, Limited (2), Manager. Dunedin, New Zealand.

ENUMERATION.

	August 1, 1895.
Honorary Members	26
Members	717
Associate Members	67
Associates	67
Students	36
Subscribers	23
Total	936

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING :

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased) ; THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased) ; Sir GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid

objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of Our Kingdom, We have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that We, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain know-

ledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of Us, Our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the Statutes of Mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments, not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. AND Our will and

pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood, shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, PROVIDED ALWAYS that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

WITNESS Ourself at Our Palace, at Westminster, this 28th day of November, in the fortieth year of Our Reign.

BY HER MAJESTY'S COMMAND,

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS.

I.—Constitution.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members, and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

II.—Qualifications of Members, Associate Members, Honorary Members, Associates, and Students.

3.—Members.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some respon-

sible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—Election and Expulsion of Members.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate, or a Student, shall be proposed according to the Forms A, B, C, or D respectively in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. The Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate.

Any person qualified to become an Honorary Member shall be proposed according to the Form E in the Appendix, in which Form the names, usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the Form F in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members, or Associate Members,

certifying a personal knowledge of the candidate, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner :—Each Member or Associate Member attending the meeting at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form G in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the Form H in the Appendix, enclosing at the same time a copy of Form I, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration in the Form I, and having likewise made the proper payment, shall receive a certificate of his election, according to the Form J.

12.—Any Member, Associate Member, Associate, or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned Form I, and paid his subscription.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the 1st of May in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form K in the Appendix, and in the event of its

continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the Form L in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members, or Associate Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute ; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form M in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted ; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion ; and if a majority of the Members and Associate Members present at such meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form N in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member, Associate Member, Associate or Student may, at any time, compound for all future subscriptions by a payment in accordance with the following scale :—

Under 30	years	of	age,	the sum of £27
Over 30	,,	,,	,,	24
,, 40	,,	,,	,,	21
,, 50	,,	,,	,,	18
,, 60	,,	,,	,,	14

or on such other conditions as the Council may, in writing, accept. Every

person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

18.—In case any Member, Associate Member, or Associate who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days

prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form O in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a List of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the Meeting.

26.—At Meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see Form P) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved by the Secretary for the Home Department,

Whitehall,
29th June, 1891 and
26th September, 1894.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-three years of age, and desirous of becoming a Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted an Associate Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Associate Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as an Associate.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted as an Associate.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM D.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being under twenty-five years of age and desirous of becoming a Student of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as a Student.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Student.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Student of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM E.]

I recommend A. B. [Christian Name, Surname, Occupation, and Address in full], from *personal knowledge*, as a person in every respect qualified to become an Honorary Member of the North of England Institute of Mining and Mechanical Engineers, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 5.*]

On the above grounds, I propose him to the Council as a proper person to be admitted an Honorary Member.

Signed.....Member or Associate Member.

Dated this.....day of..... ...18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Honorary Member.

FROM PERSONAL KNOWLEDGE.

....
.....
....
.. ..
....

} Five Members or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of..... .....18 .

[FORM F.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a.. .....of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-three years of age, and being desirous of becoming a Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this..... day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

....} Two Members or
....} Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this..... .. day of.....18 .

[FORM G.]

List of the names of persons to be balloted for at the General Meeting on..... the.....day of.....18 .

MEMBERS :—

.....

.....

ASSOCIATE MEMBERS :—

.....

.....

HONORARY MEMBERS :

.....

.....

ASSOCIATES:—

.....

.....

STUDENTS:—

.....

.....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM H.]

SIR,—I beg leave to inform you that on the .....day of..... you were elected a.....of the North of England Institute of Mining and Mechanical Engineers. In conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription be paid, the amount of which is £....., or, at your option, a life-composition in accordance with the following scale:—

Under 30 years of age	...	...	...	...	...	...	£27
Over 30	,,	,,	...	...	...	...	24
,, 40	,,	,,	...	...	...	...	21
,, 50	,,	,,	...	...	...	...	18
,, 60	,,	,,	...	...	...	...	14

If the subscription is not received within two months from the present date, the election will become void under Bye-law 10.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM I.]

I, the undersigned, being elected a.....of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this.....day of.....18 .

[FORM J.]

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

Founded 1852. Incorporated by Royal Charter, A.D., 1876.

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of the North of England Institute of Mining and Mechanical Engineers, at a General Meeting held on the.....day of .....18 .

Witness our hands and Seal this.....day of.....18 .

Seal

.....President.

.....Secretary.

[FORM K.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM L.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £.....is made previous to the.....day of.....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM M.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM N.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the.....day of.....18....., according to the provisions of Bye-law 15, you have ceased to be a.....of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM O.]

BALLOTING LIST,.....

Ballot to take place at the Annual Meeting on.....18.....at Two o'clock p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.*

_____ } New Nominations.*
_____ }

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

_____ } Vice-Presidents for the current year eligible for re-
_____ } election.
_____ }

_____ }
_____ } New Nominations.
_____ }
_____ }

COUNCIL—Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

_____ }
_____ }
_____ }
_____ }
_____ } Members of the Council for the current year eligible for
_____ } re-election.
_____ }
_____ }
_____ }
_____ }
_____ }

_____ }
_____ }
_____ }
_____ } New Nominations.
_____ }
_____ }
_____ }
_____ }

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS, or
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

EX-OFFICIO MEMBERS of the Council for the ensuing year:—

_____ } Past-Presidents.

_____ } Retiring Vice-Presidents.

Extract from Bye-law 21.

Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. [See Form O in the Appendix.] A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20:—

AS PRESIDENT .....

AS VICE-PRESIDENT .....

AS COUNCILLORS .....

[FORM P.]

Admit .....

of .....

to the General Meeting on Saturday, the .....

(Signature of Member, Associate Member, Associate, or Student) .....

The Chair to be taken at Two o'clock p.m.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor) .....

Not transferable.

TN
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N8
v.44

North of England Institute
of Mining and Mechanical
Engineers, Newcastle-upon-
Tyne
Transactions

Engineering

~~Physical &~~
~~Applied Sci.~~
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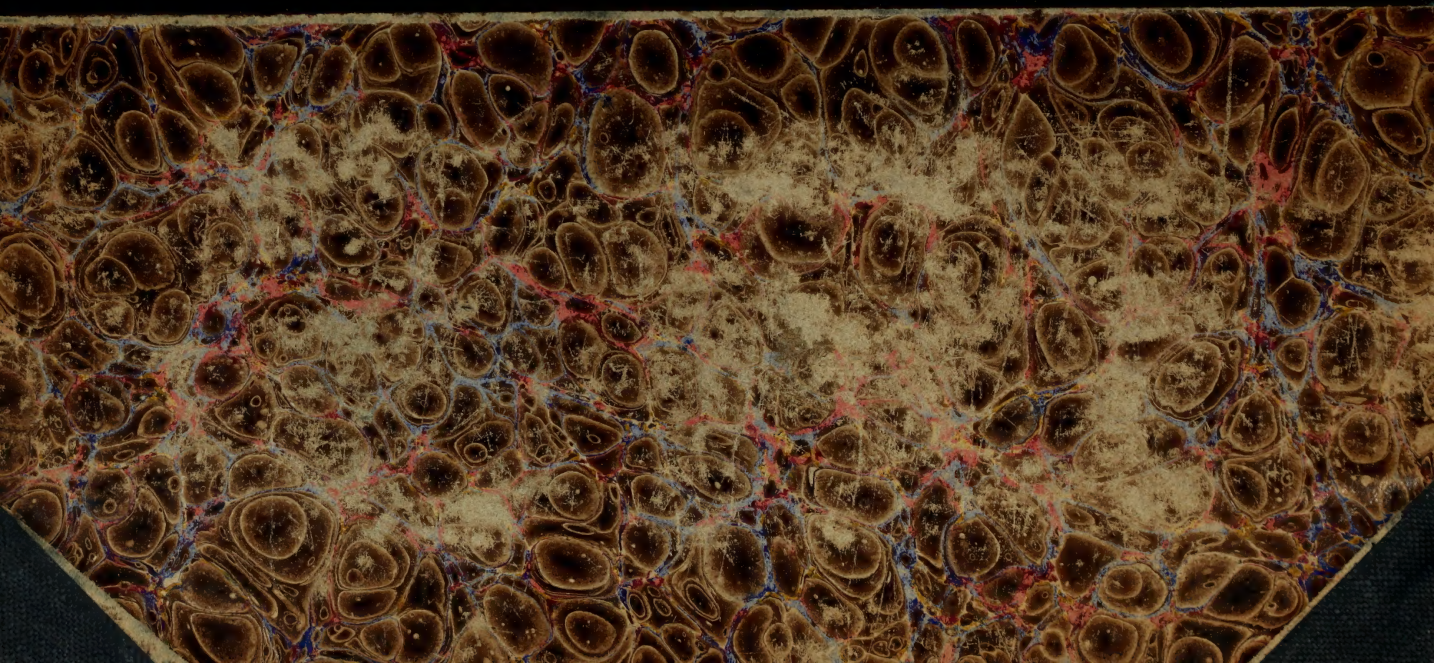
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